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IRON AND STEEL ENGINEER

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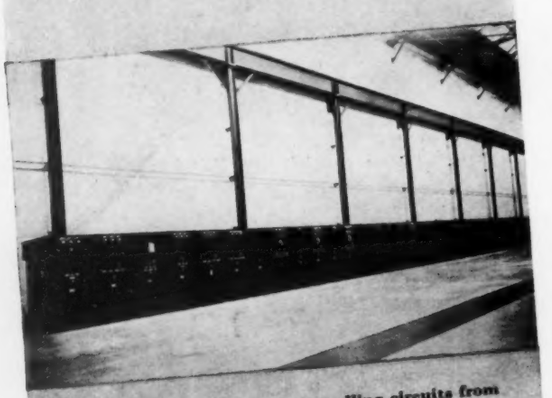

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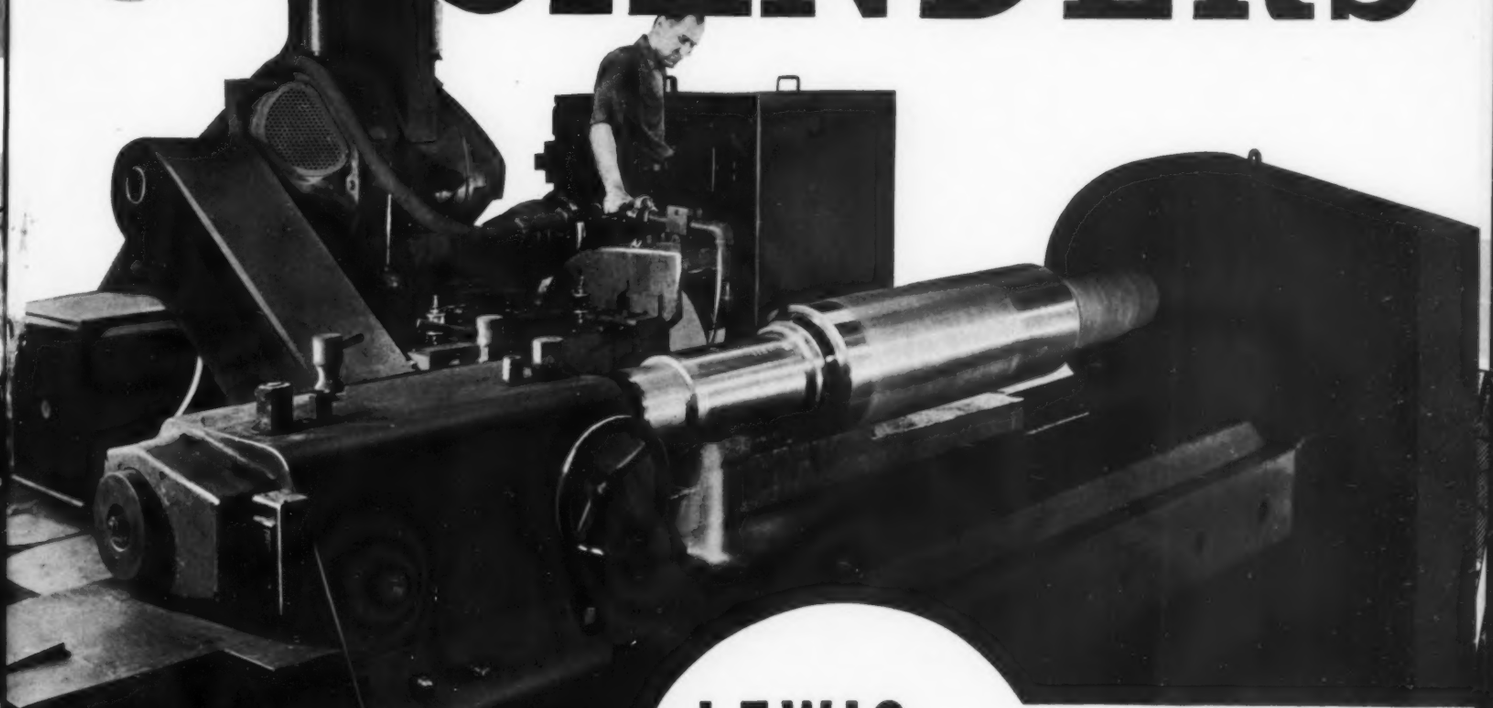

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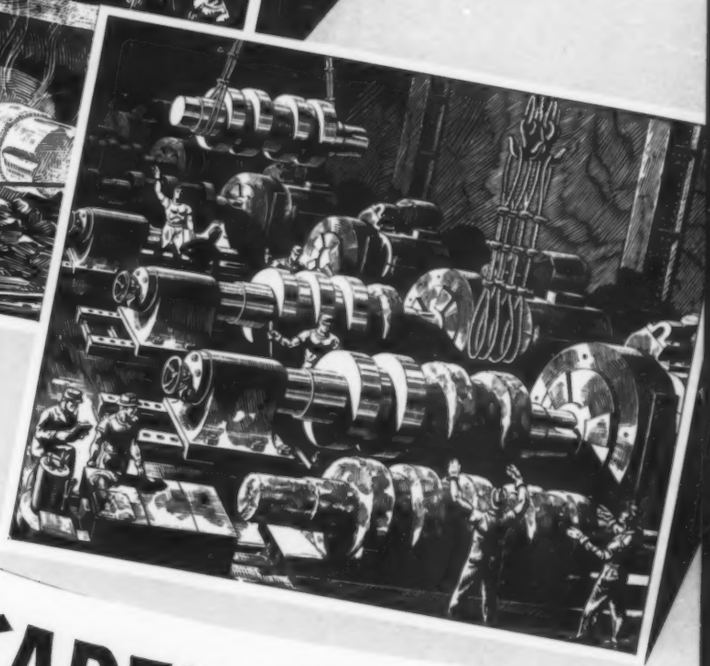
MODERN ROLL TECHNIQUE



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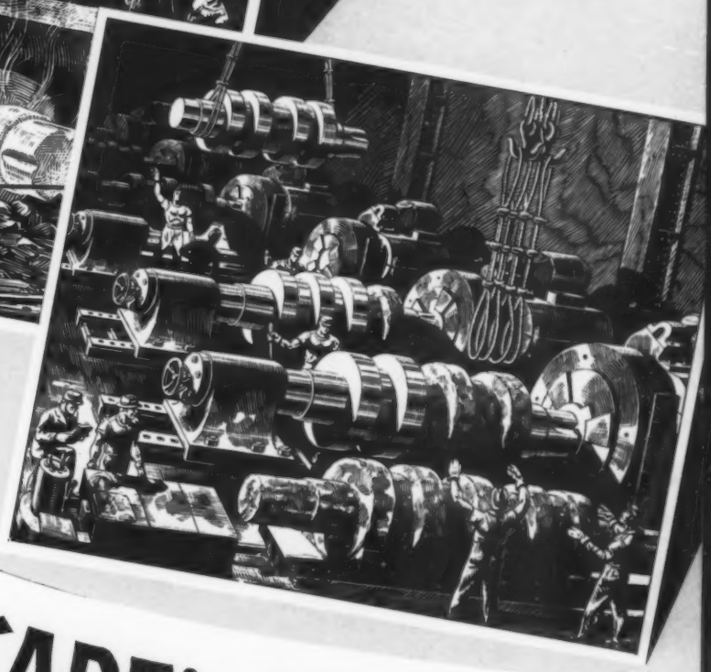

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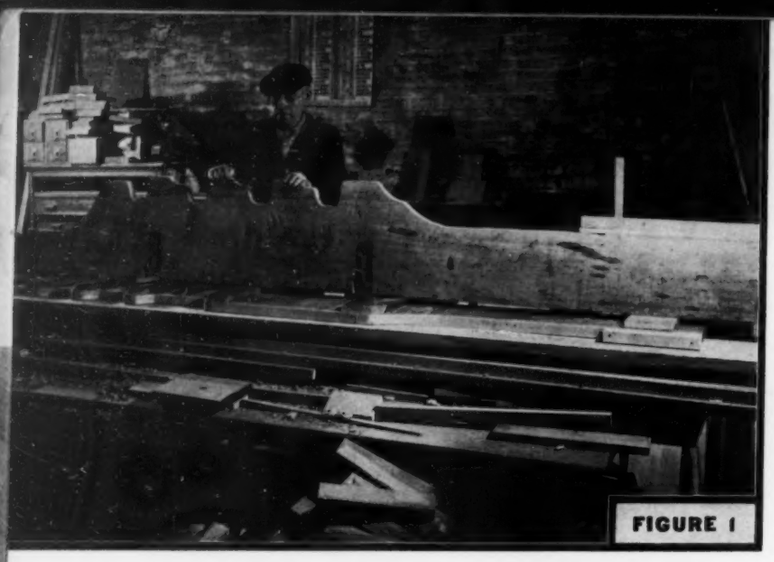


FIGURE 1

MANUFACTURE and IRON and ST

PART 1—THE MANUFACTURE

By **W. H. WHITE**

▲ I WOULD like to open my remarks by saying that I am not as thoroughly acquainted with rolling mill practice as I would like to be. I am a foundry man producing the tools with which you work. By this I mean rolls. After all, when a mill has had its various first operating problems ironed out, rolls are then the tools to which you look for continuous performance of service in order to produce material of the highest grade.

As we look back over the years, we see the results of step by step progress of our efficient engineers, roll designers, and operators in the steel industry. To them goes the credit for leadership that keeps our country far in front in the production of steel—a metal as valuable to us as gold and silver. By reason of the close working relationship between the technical men in the steel and allied industries, we are as units, competitors to the world.

With this thought in mind, I give you what little knowledge I can of the 60 years' of experience the men of my company have gained in keeping in step with your demands for better rolls to help in the production of your higher-grade materials.

Foreword

Mr. White's paper was delivered in the form of comment on a series of lantern slides. In order to approximate the published form of the paper as nearly as possible to its form of delivery, we present it pictorially with the comment accompanying each illustration.

Presented before the Annual Convention of the A. I. & S. E., Chicago, Ill., September 28, 29, 30, October 1, 1937

From the first straight iron and plain steel rolls, we have taken many steps in the production of alloys, both in iron and steel. In fact this trend has been such that I might safely add that only a few among all roll manufacturers show much tonnage today in the straight iron and plain steel family.

In the classification of iron, we have the clear chill,

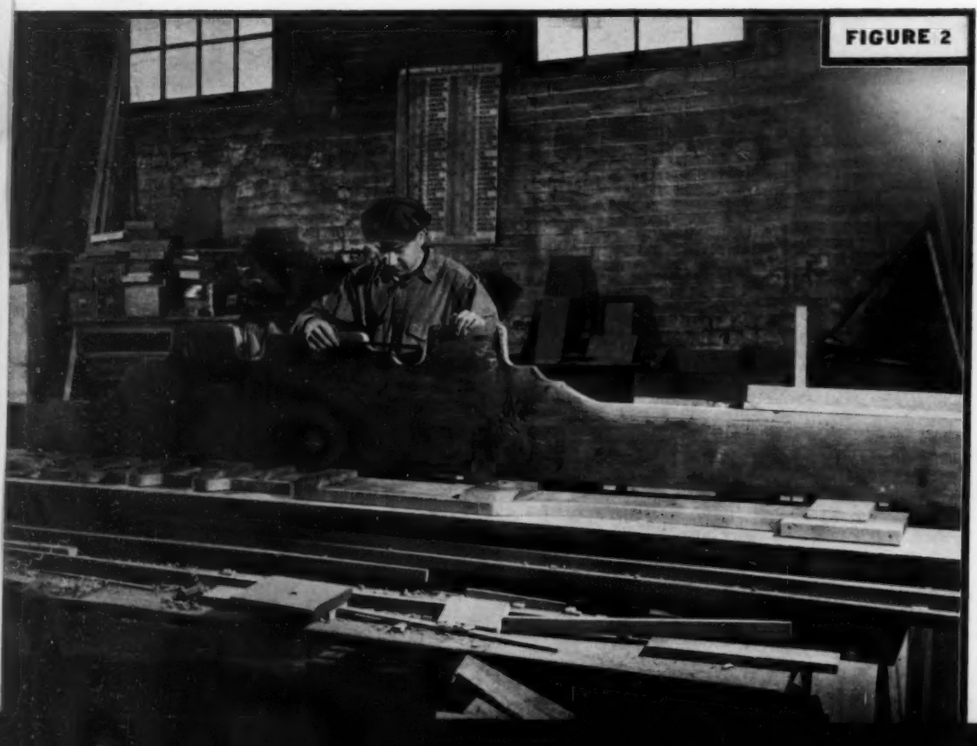


FIGURE 2

W. H. White

R and USE of an STEEL ROLLS

By

W. H. WHITE
General Superintendent
F. L. MacQUARRIE
Chief Engineer
Pittsburgh Rolls
a division of the
Blaw-Knox Company
PITTSBURGH, PENNA.

the grain and the high alloy—in most cases, plain rolls.

In the classification of steel, we have the low carbon; and low carbon to us is .50 per cent to .80 per cent; the medium carbon say .80 per cent to 1.40 per cent; the high carbons 1.40 per cent to 2.60 per cent. Most all of these carry alloys, and in most cases, they are shape rolls.

FIGURE 3

You have helped us develop this practice to meet your demands, and for this we are grateful. With these introductory remarks, I will now carry you through the manufacture of someof these rolls, hoping I can leave a little clearer thought in your mind as to what all roll makers have to do in order to produce a sound, satisfactory tool for your mills.

The first step in the making of any roll is the production of a pattern. Roll patterns differ from ordinary foundry patterns in that they are of the sweep type and represent the contour of one half of the roll. Here in Figures 1 and 2 we see the checking of the finish in the passes of a 27 by 56 inch edging rail roll. Naturally, allowance must be made for shrinkage so that we shall have a sufficient amount of metal to allow for finishing after the roll has been cast.

An important element in the production of most rolls is the preparation of the chills. In Figure 3 we see the molding floor for chills that are used on plain and shaped rolls. These usually are made of cast iron and are designed and cast before molding can begin on any rolls. In our plant, tons of these are made each day as they can seldom be used twice.

Previous to molding, both the bare chills and sand covered chills must be thoroughly cleaned before placing in the mold. The picture Figure 4 illustrates typical designs and shapes of chills used for various types of rolls and the methods used for cleaning.

F. L. MacQuarrie

FIGURE 4

FIGURE 5

We have found that group moulding is the most desirable practice in casting small Phoenix Metal rolls. (Figure 5.) The bottom wobblers and necks are molded and dried separately while the bodies are cast in solid chills in the same manner as regular iron chilled rolls.

Extreme care is required in setting the chills. The illustration (Figure 6) shows the setting of a bare chill in a top or bottom second edging roll for 100 pound rails. Each quarter section chill weighs about 150 pounds amd the total weight for one pass is 600 pounds. To prevent these chills from falling out or moving, they have to be securely fastened to the flask. The burning or distortion which takes place during the course of the casting provides the reason that chills can seldom be used twice. This particular roll is cast from Phoenix Metal of 2.00 per cent carbon alloy, and the temperature of the metal must be within 50 degrees F. of a fixed range. If the pouring temperature is too high, it will burn the chill, releasing the cast iron within the finish and providing an interchang of the molten metal with the metal of the chill. If the temperature is too low, solidification becomes too rapid, causing irregular contraction or extreme surface tension of the roll metal against the chill. This will result in surface cracks.

We have previously shown a picture of the pattern. Figure 7 shows the method of molding a 24 by 52 inch beam roll by using the sweep for one-half of the body and neck with the flask acting as the body of the chill.

Following the molding of the sand with a sweep type of pattern and the placing of the chills, the mold must be finished. Figure 8 depicts a mold for a second edging 80 to 90 inch rail roll. The iron chills can be noted in the work passes. These chills are in quarter sections, and the joints, if not close, will cause cracking because the sand is somewhat of an insulator and gives a different ratio of cooling than the chill.

Following the completion of molding, the molds are placed in drying ovens. (Figure 9.) The medium size rolls can be dried, as a rule, in 24 hours and the molds are usually hot at the time the pouring is done.

Due to the weight of the iron chills, it is necessary to brace them in the flasks, particularly in the case of large rolls (Figure 10) to prevent the chills from falling when the flask is rolled over for placing on the drag.

FIGURE 6

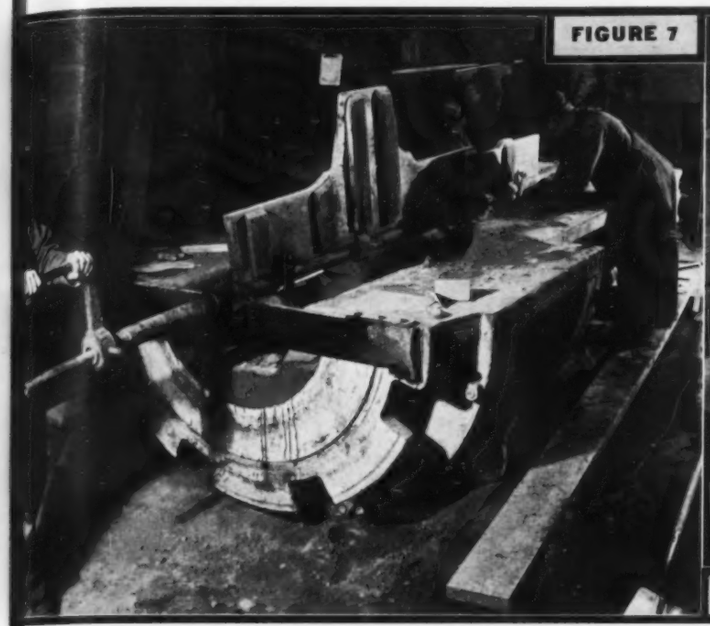


FIGURE 7

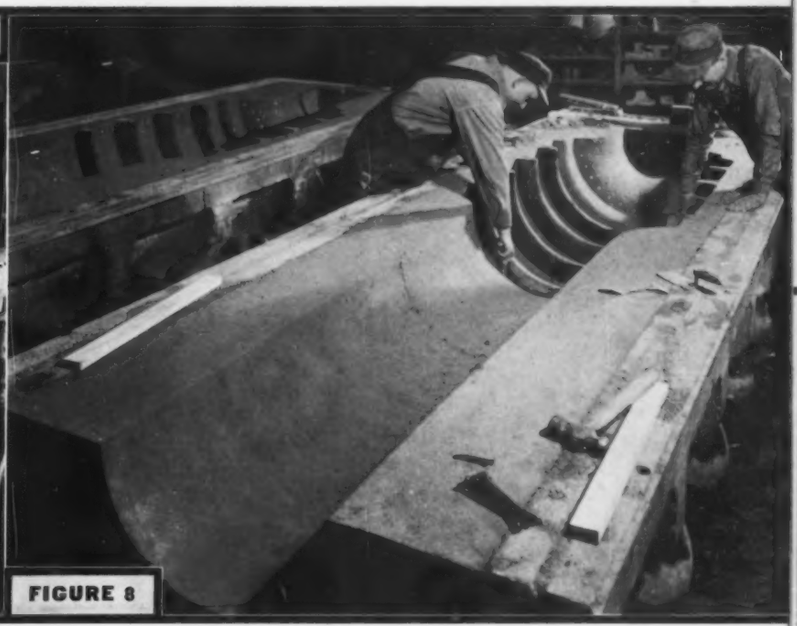


FIGURE 8

FIGURE 9

FIGURE 10

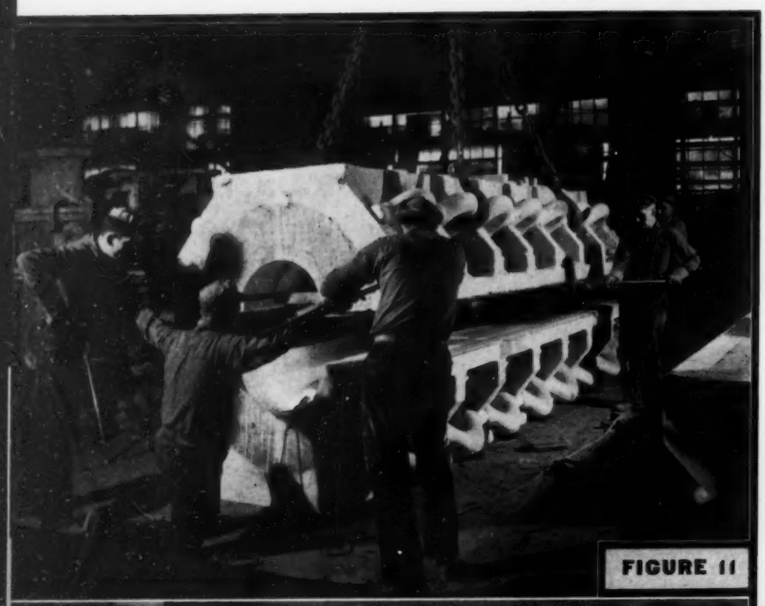


FIGURE 11

FIGURE 12

FIGURE 13

With the completion of these operations, the mold is ready for closing. Figure 11 shows the closing of the cope on the drag of a second edging rail roll. All rolls are poured in an upright position, the metal coming in a down gate on the bottom neck in a tangential position to give the metal a swirl which is necessary for satisfactory casting.

Materials used in the making of rolls must be stored carefully and according to composition. (Figure 12.) The melt down on all roll heats over 1.40 per cent carbon must be within range of finished analysis, as iron ore cannot be used without serious results. It

FIGURE 14

is impossible to work a high carbon heat, therefore the refining period consists mainly of adjusting composition and obtaining the correct pouring temperature, most heats being too hot to pour when they are melted. If we are making a 2.30 per cent to 2.40 per cent carbon roll, we charge about 2.70 per cent carbon and will melt about 2.35 per cent. If slag and furnace conditions are correct, very few points of any element are lost over a period of two hours and this time is consumed in making alloy additions and obtaining proper pouring temperature.

FIGURE 15

We have found in the course of our experience a highly satisfactory test, which is illustrated here. (Figure 13.) This shows the melter taking a temperature test. This is done by slagging the spoon and filling it with steel as it passes through the wicket hole. A stop watch is started, and when an oxide film completely covers the metal, the watch is stopped. The number of seconds then is recorded and is compared with previous heats. As an example, when we have found on previous heats of the same analysis that satisfactory castings were secured after the film formed in 10 seconds, we have a fairly satisfactory rule of thumb for subsequent heats. This test, of course, is supplemented by other tests, but it has been found to be extremely valuable over the course of a long period.

Figure 14 is a picture of a molten air furnace heat. The white area indicates points where the slag is a little thicker and consequently a little hotter, which makes it brighter on the picture. This phenomenon points out the insulating effect of slag and its protective use to molten metal.

On certain compositions of iron rolls, the sulphur runs as high as .15 per cent, and the sulphur yield is made more reliable by adding pyrites in the ladle than by adding it in the furnace. (Figure 15.)

FIGURE 16

All rolls are poured in a vertical position and the steel base rolls are all bottom poured. Figure 16 shows a group of four small rolls being poured from one center down gate.

The method of pouring shown here is used mostly for iron rolls. (Figure 17.) It is called lip pouring. Observation of the metal for correct pouring temperature is an advantage secured in this method over bottom pouring.

FIGURE 17

FIGURE 18

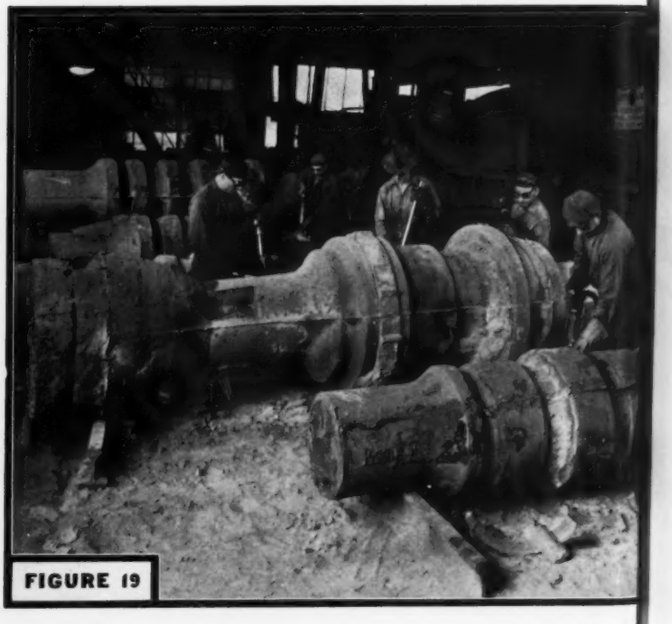


FIGURE 19

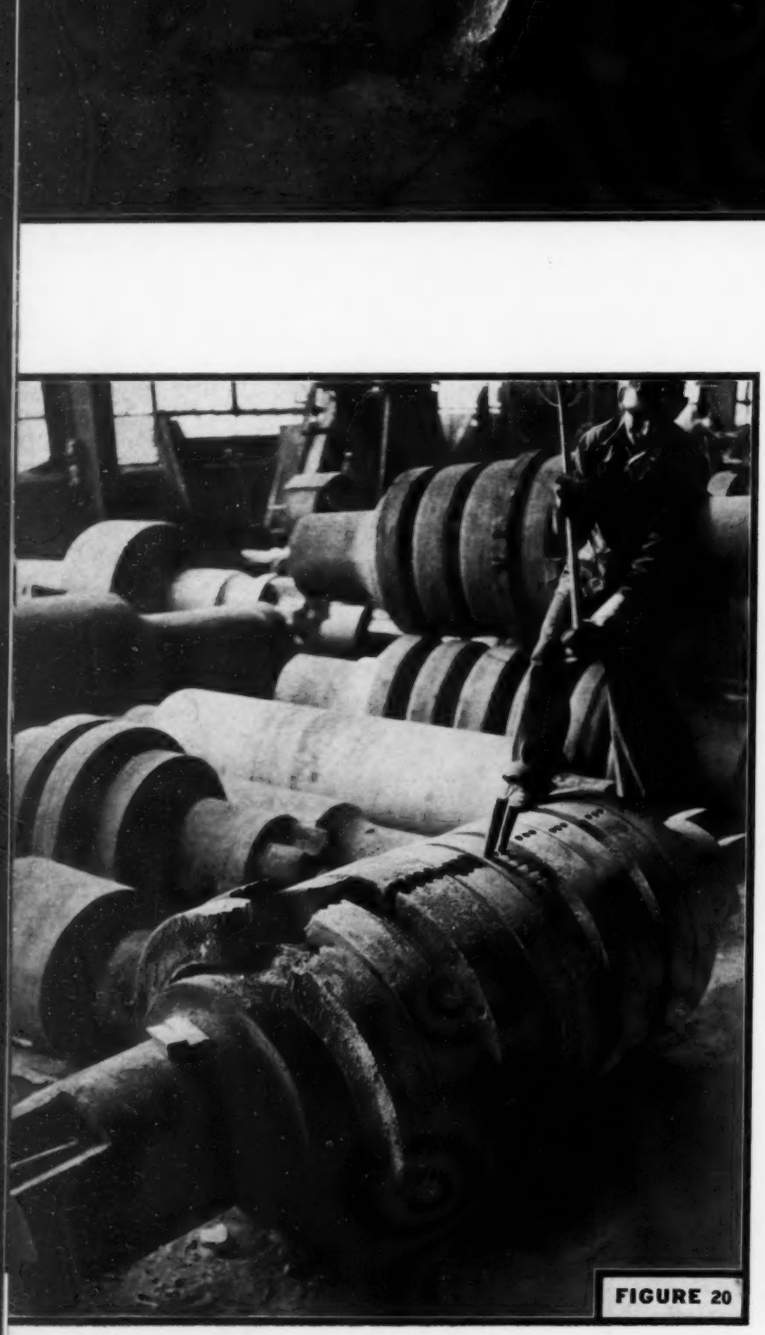


FIGURE 20

By burning with a water cooled oxygen torch, shown in Figure 18, it is possible to cut a thirty-five inch diameter shrink head before the roll goes to the heat treatment furnace. Since our cost of heat treating is in a direct ratio to the tonnage put in the furnace, this practice saves the cost of treating the discards and allows us to put greater tonnages of actual rolls in the treatment furnaces. (Figure 18.)

Figure 19 shows a view of the cleaning floor during the removal of the chills and sand from the passes before the rolls go to the roll shop.

It is necessary to drill and wedge off the heavy cast iron rings, Figure 20, used to chill the passes of an inter-

FIGURE 21

FIGURE 22

mediate six by six inch angle roll made of grain metal. The heavy cast iron rings chill the metal in the same manner as the chill mold for the ordinary chill roll. It is possible to obtain a close grain condensed metal for a depth of three to four inches with this method of molding. This is difficult and costly but produces a sound and satisfactory grain structure.

In order to handle the large volume of machine work necessary to finish rolls, a battery of small lathes is required for machining the smaller iron and steel rolls. (Figure 21.)

Figure 22 shows a large battery of roll lathes. It will be noted in this view that shaped rolls are more numerous than plain rolls.

(Figure 23.) This shows a 42 by 120 inch work roll for a large plate mill. This roll requires both strength and hardness and is made of medium carbon alloy. Its weight is about 98,000 pounds and it requires about three weeks for heat treatment. A long plain body roll of this type will shrink two inches in length and internal cracks may occur if freedom of movement is hindered.

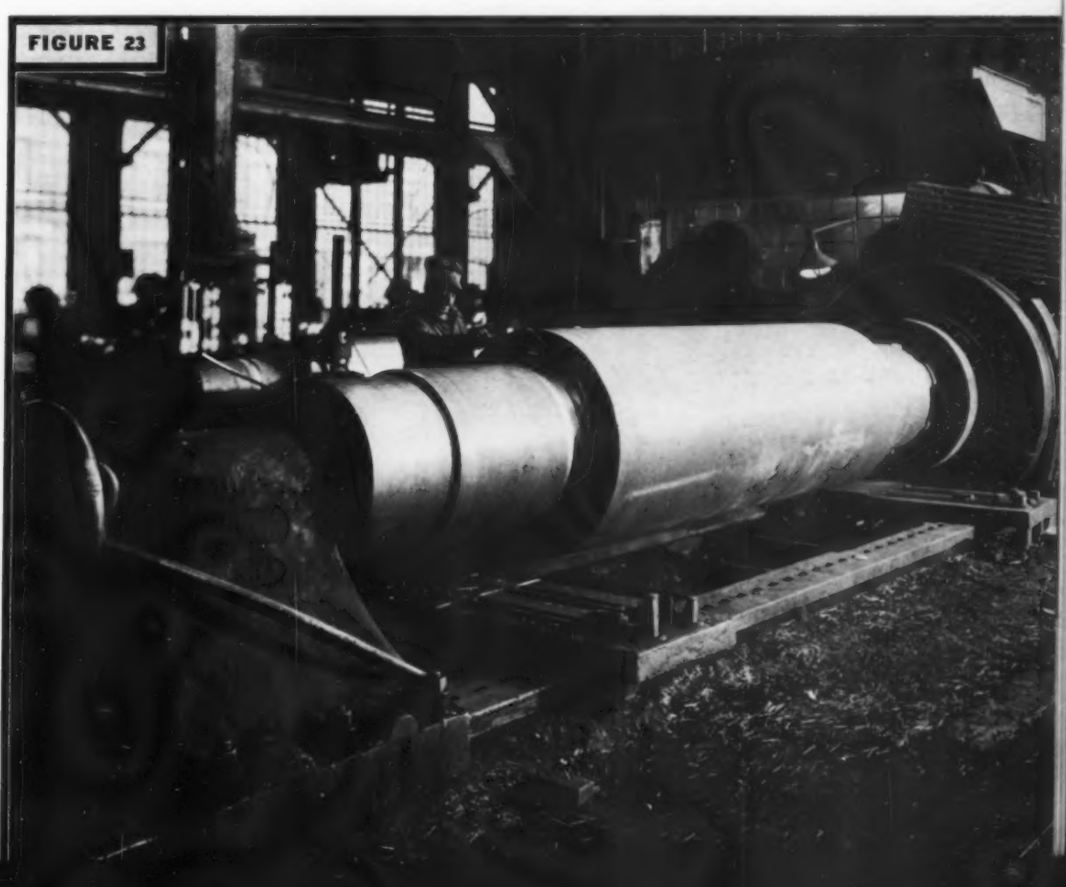


FIGURE 23

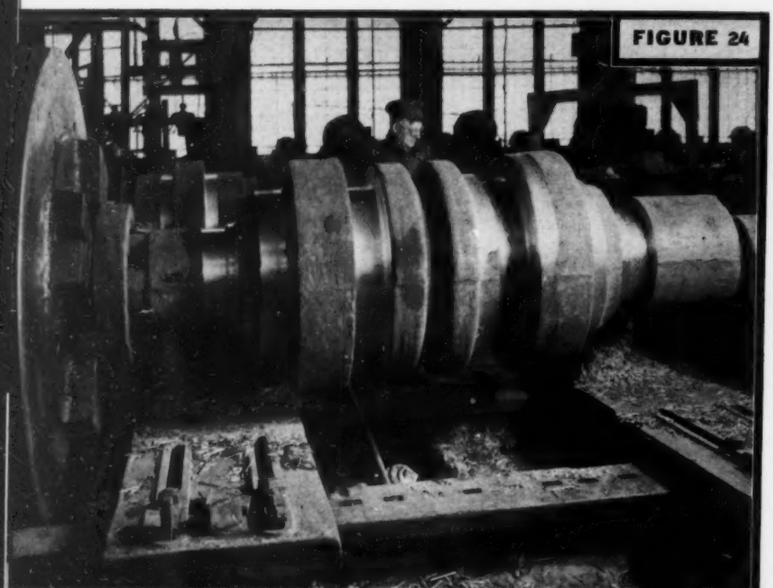


FIGURE 24

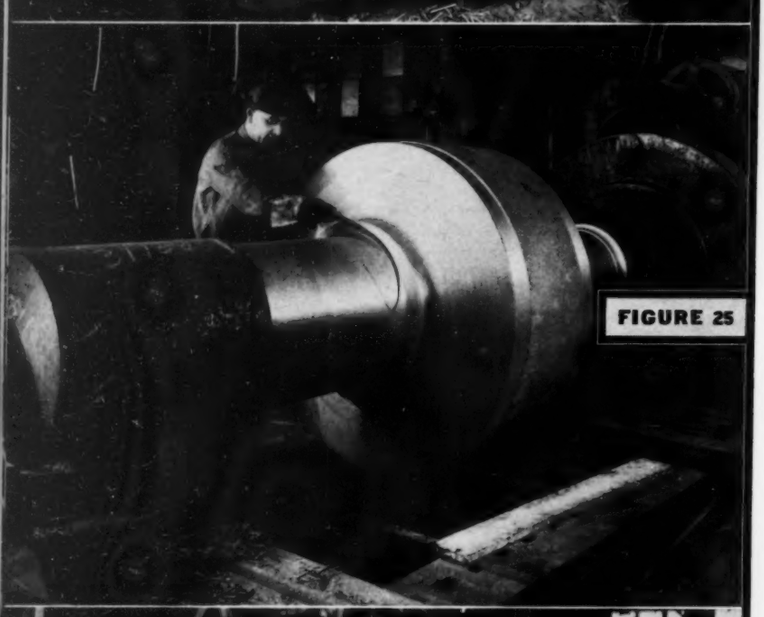


FIGURE 25

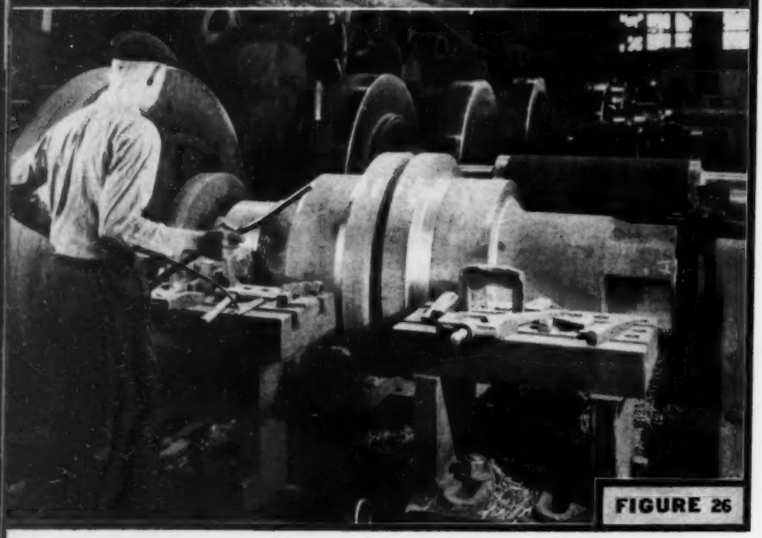


FIGURE 26

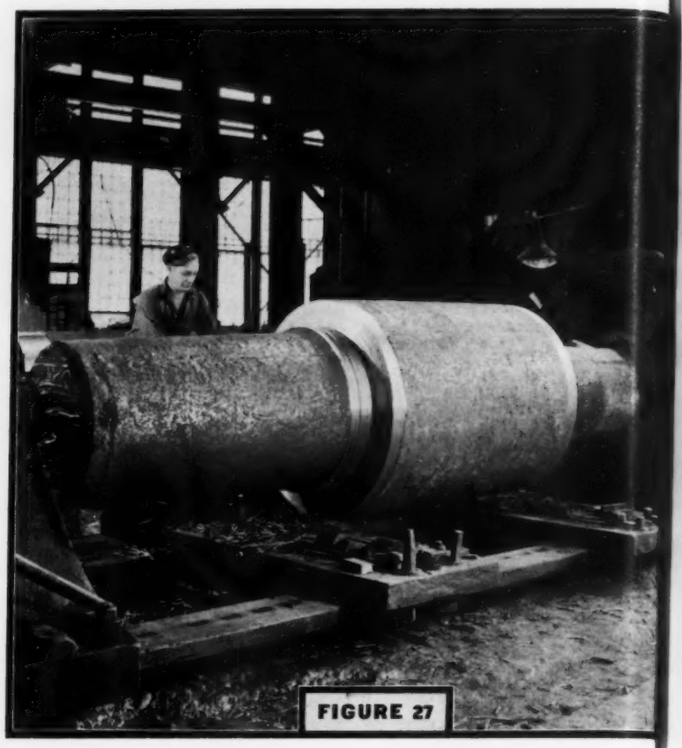


FIGURE 27

Skill and judgment are required to produce a sound metal and to prevent surface cracking of this 29 by 64 inch finishing roll for seven inch grooved street car rails. This roll (Figure 24) is made of Phoenix Metal.

This 52 by 24 roughing beam roll (Figure 25) is a type which when first produced, caused all makers trouble because of the large diameter body in comparison with the necks. Many of them either blew up before going to the heat treating furnace or after they were put in the furnace. This was due to irregular expansion and contraction of the body against necks. Most of us overcame our problems years ago on this type of roll and now really like to make them, even though they require special equipment in the foundry and careful handling while under temperature.

This 26 by 31¼ collar rail finisher (Figure 26) for 3⅞ to six inch flange rails is difficult to mold and cast as it requires a deep chill and a built up molding job.

Figure 27 is an example of a case where the stock on the top neck is greater than the stock on the bottom neck. The roll is made in this way because there must be a diameter large enough to prevent choking off of the feed metal from the shrink head to the body as shown on this 42½ by 42 inch backing up roll with long necks.

A 54 by 120 inch backing up roll shown here in Figure 28 is in the lathe to have the head cut off. This roll takes 150,000 pounds of metal to pour and is shipped at 100,000 pounds. It is made of a special high alloy steel.

To obtain a sound body on this 24 by 42 inch straightening roll, Figure 29, it is necessary to have an upper neck and head of sufficient diameter to feed the body. This means turning off this excess metal which in all

cases is the best metal in the roll. This type of neck makes a different foundry problem.

Figure 30—Morgoil bearings were used on this 13¼ by 27⅜ inch rod mill roll made of chill iron with a chill of about one inch depth. These bearings necessitated very accurate neck and body dimensions. Special couplings are used and these rolls are machined on both engine and roll lathes that must be mechanically perfect to produce this close tolerance job. We are allowed only .002 tolerance on most rolls. The grinder (Figure 31) is measuring a 20½ by 54 inch 80-hard roll for dimension.

I might discuss some of the difficulties which are encountered in the manufacture of a hard unmachinable cast type of roll where the surface requirements are so rigid that most of the defects encountered are invisible to the naked eye in a finished roll unless the roll be highly polished or sand blasted.

Assuming sufficient inherent strength has been built into the roll for the service required, any surface defects can only be eliminated by careful planning and supervision of each operation entering into the manufacture and is seldom the result of any one particular factor such as chills, melting temperature, cooling or heat treating.

While progress has been made in developing hard high nickel rolls for use in four-high finishing mills there still remains much research work to be done before the ideal roll is obtained for this purpose. There are as many different types of this kind of a roll as there are roll markers, and rightly so, since there are many variations in mill practice as well as in the four high mill itself.

FIGURE 28

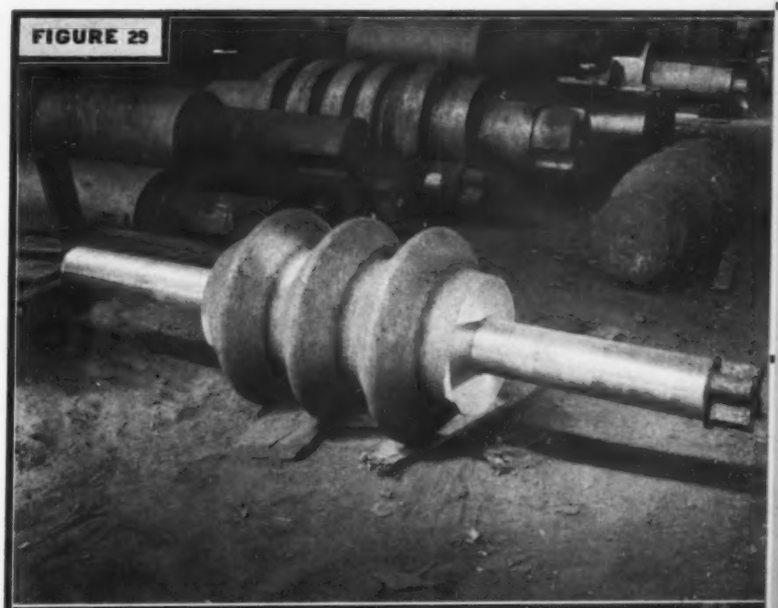


FIGURE 29

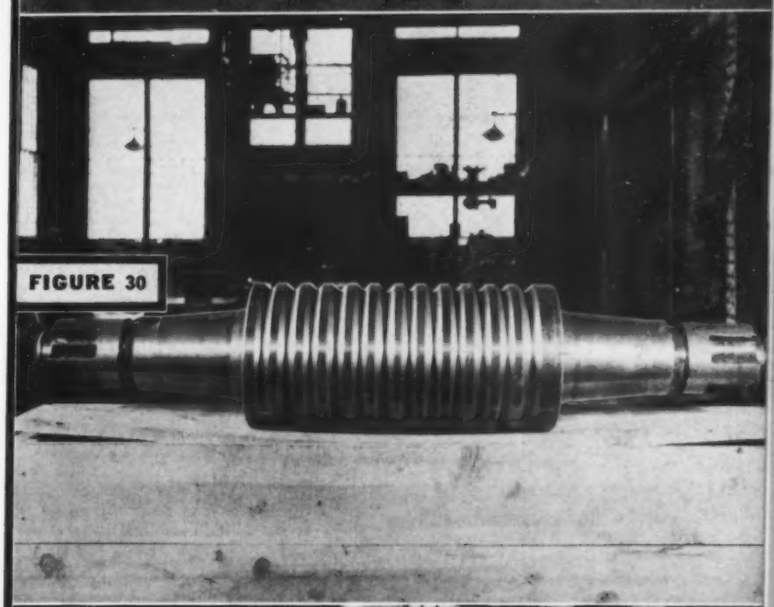


FIGURE 30

FIGURE 31

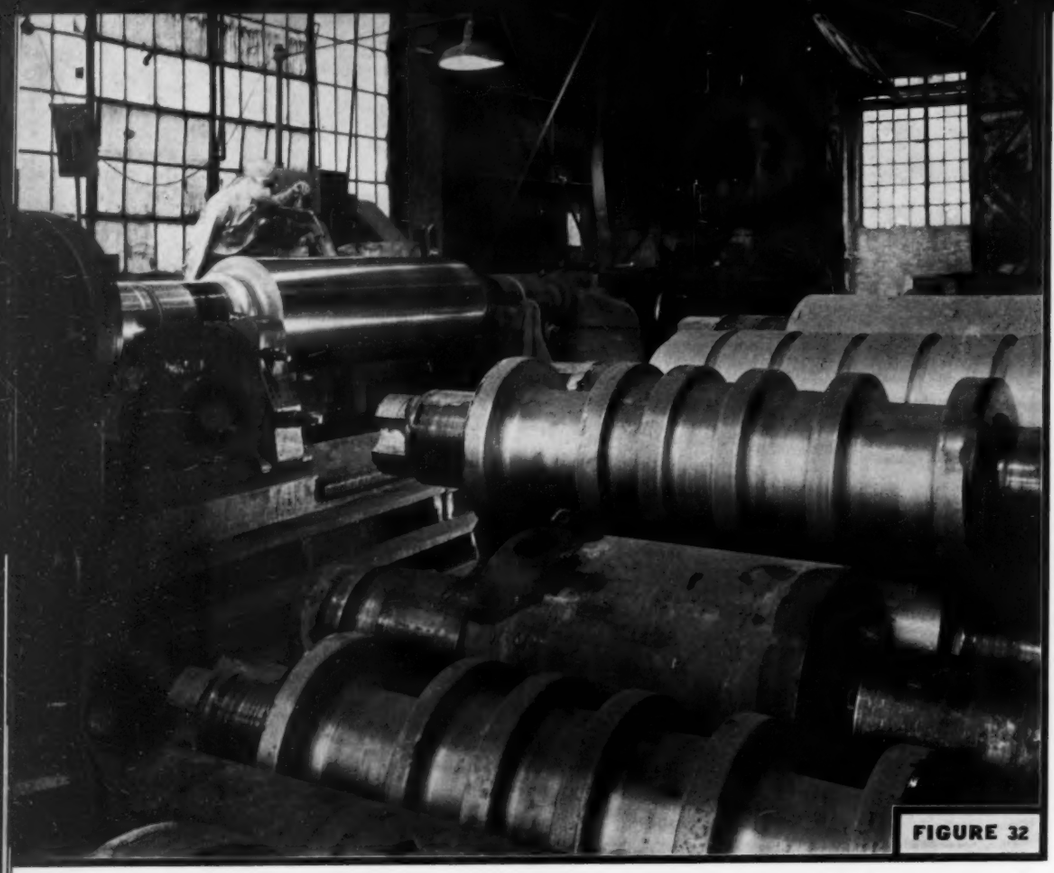


FIGURE 32

For this reason it has been found impossible to generalize on either the manufacture or use of a 4-high mill rolls and likewise any discussion of specific rolls or uses is omitted for obvious reasons.

Mirror finishing a 20¼ by 55-inch Phoenixloy iron roll within close dimensions is shown in Figure 32. This roll is not machinable as it runs from 75 to 95 hard. It has to be free of surface defects that only a mirror or sand blast finish can expose. It is used for both hot and cold rolling of high grade strip. It differs from the forged steel roll in that its hardness is inherent and runs approximately the same from surface to core where the forged roll receives most of its hardness by selective heat treatment. There is a four to six point difference in the hardness of bodies and necks due to the sand mold for necks and chill molds for bodies.

Figure 33 shows a 36 by 110 inch nickel chill roll for a 3-high plate mill cracked on the lower section of the body. The crack begins on the shoulder extending horizontally along the body for about 24 inches. The cause of this type of crack is temperature and time of pouring. The answer:—Every composition has its correct pouring temperature and every size has its pouring time. Circumferential cracks which many times do occur at joints only are caused by gas from the blackening being trapped at the joints. The metal travelling upwards so rapidly overlaps the gas, which is an insulator causing a hot ring that tears, due to the irregular ratio of solidity in this area.

FIGURE 33

FIGURE 34

FIGURE 35

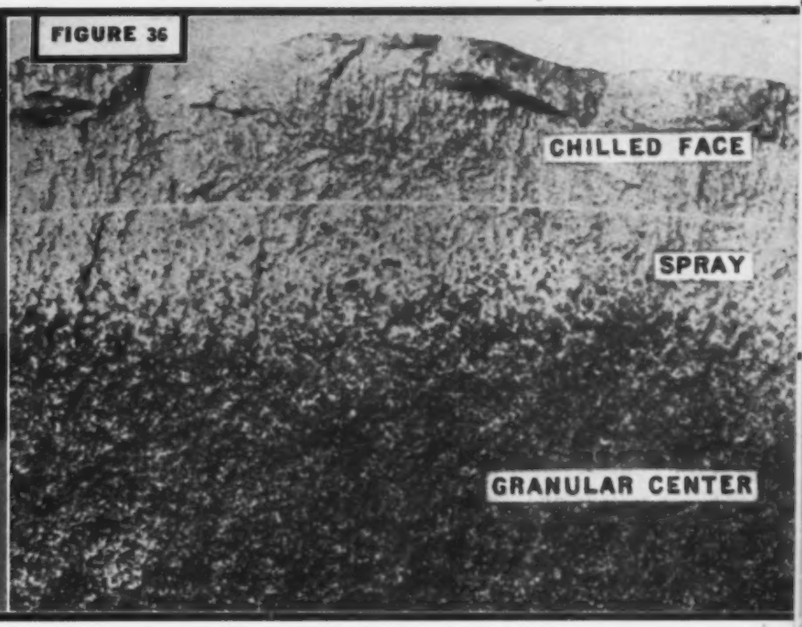


FIGURE 36

Figure 34 is a chill roll which has given its full life of service. Note the depth of chill remaining.

In this photograph (Figure 35) is shown the progressive modifications of a large diameter high alloy cast steel roll due to heat treatment.

No. 1, upper left, shows the course columnar crystal structure in the "as cast" condition.

No. 2, upper right, shows the refinement after the first normalizing heat.

No. 3, left center, shows still further refinement and considerable toughening after air quenching from a second grain refining temperature.

No. 4 and No. 5, right center and bottom left and right, show a silky and a very tough cast steel structure after a strain relieving treatment.

Figure 36 is an excellent picture of a cross section of a plain chill roll showing clear chill, also the mottled field that lies between the clear chill and grey back.

To foundry men who may be present, Figure 37 is a very simple picture of a chill mold set up, but I thought it would be interesting to some others in that it shows the cast iron chill, the sand drag and neck, and the method of gating.

I hope that this discussion of the salient features of roll production has given you at least some understanding of the problems involved, and of the methods used in making your tools.

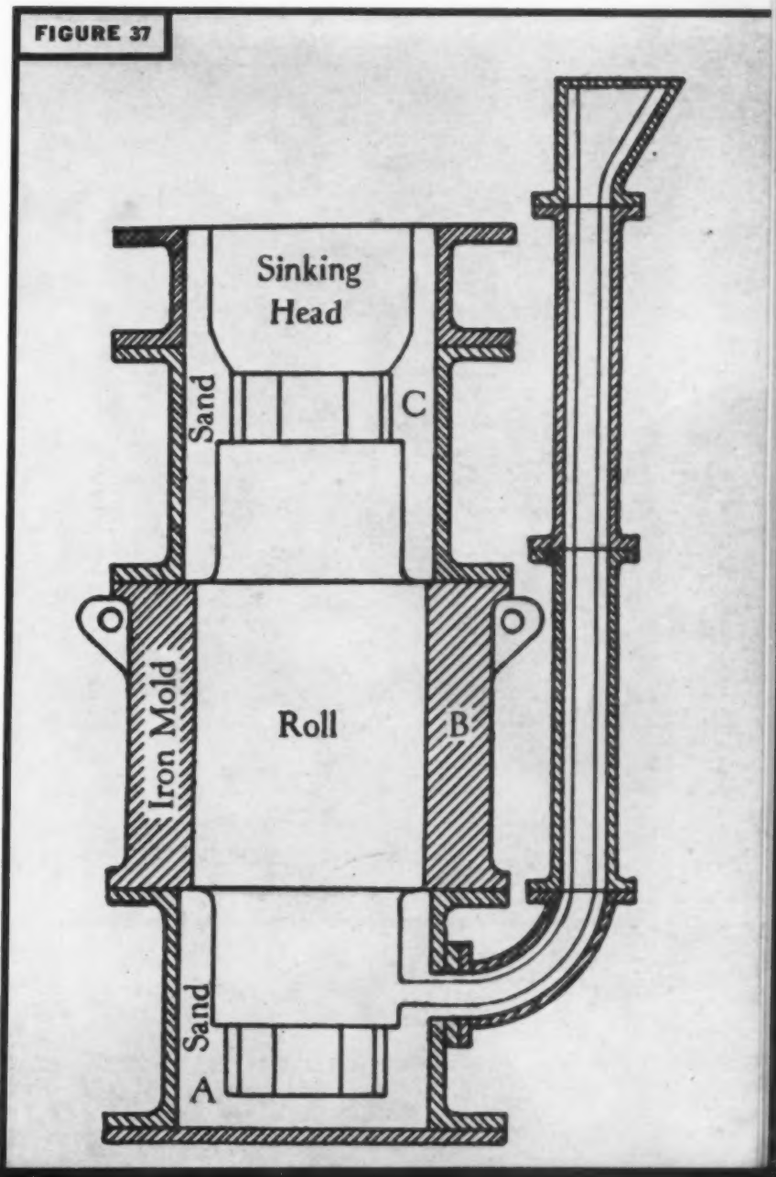


FIGURE 37

PART 2—THE USE

By **F. L. MacQUARRIE**

▲ THE purpose of my efforts in the ensuing paper will be to show some of the uses and misuses to which rolls are subjected; the general aim of all roll manufacturers to make rolls suitable to a great variety of uses; some of the variables encountered in rolling mill practice which make the manufacture of rolls a difficult problem; and the need for intense study which would lead to actual knowledge of the multitude of variables which enter into the deformation of steel, iron, and other metals in rolling and, by so gaining this actual knowledge of these variables, convert the present *art* of roll design into the exact science which it will, one day, become.

In the year 1550, a Frenchman, named Brulier, first rolled sheets of metal to uniform thickness for the purpose of making coins of equal weight.

In the year 1754, Henry Cort of England built the first mill for the rolling of iron.

In the year 1783, after experimenting for a number of years, this same Henry Cort was granted British Patent No. 1351 for "grooved rolls for rolling iron."

From the data at hand, this was the first attempt at roll design.

In the intervening years since that time, much knowledge has been gained relative to roll design. In the rolling of simple sections such as blooms, billets, rounds, squares, flats, ovals, etc., most of the variables encountered have been analyzed, and fairly definite formulae have been worked out. Some of these are: The relation of elongation to draft, which, under normal circumstances is directly proportional; relation of spread to draft; limits of angle of contact and controlling or working diameter of passes, i.e. corresponding pass speed at which a bar is being delivered. (Figure 1.)

When we go beyond the simple standard sections such as rounds, squares, and flats, or sections approximating these, and into the more complicated shapes wherein we encounter both direct and indirect draft being applied at one time, at varying degrees from the

COMPARISON OF VARIOUS METHODS FOR FINDING THE WORKING DIAMETER OF DIAMONDS, SQUARES AND OVALS

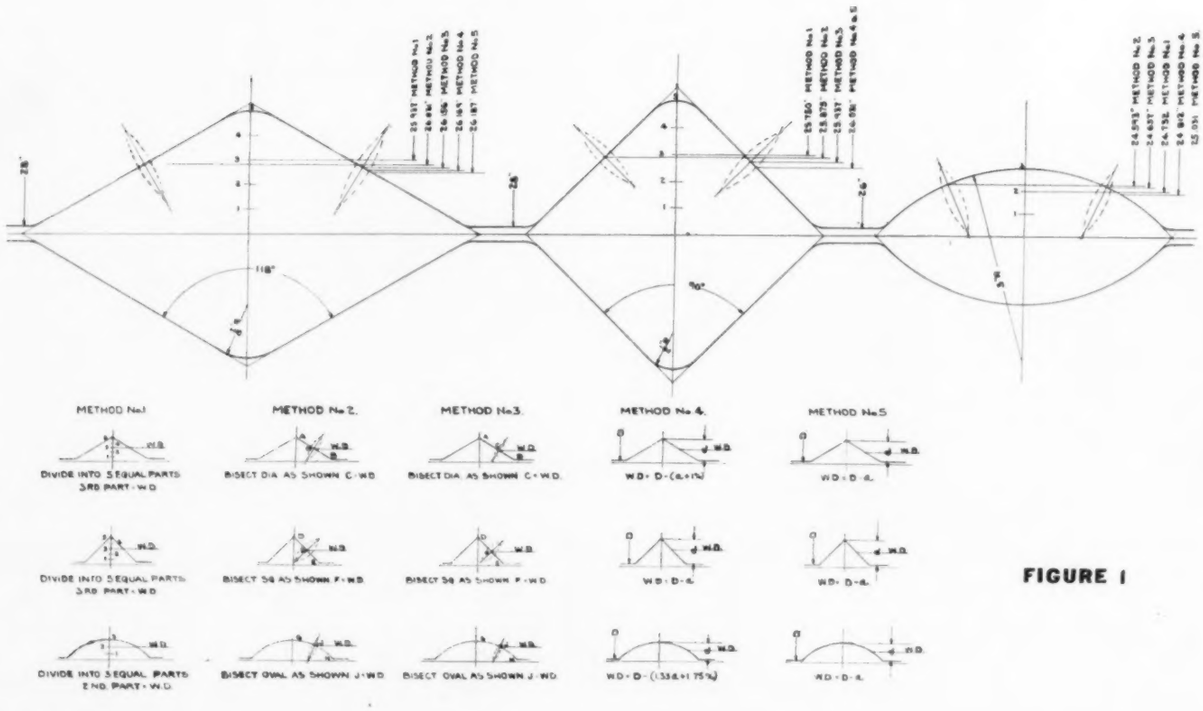

METHOD No.1
METHOD No.2.
METHOD No.3.
METHOD No.4.
METHOD No.5
DIVIDE INTO 5 EQUAL PARTS 3RD PART = W.D.
BISECT DIA AS SHOWN C = W.D.
BISECT DIA AS SHOWN C = W.D.
W.D. = D - (.6 + 1%)
W.D. = D - .6
DIVIDE INTO 5 EQUAL PARTS 3RD PART = W.D.
BISECT 36 AS SHOWN F = W.D.
BISECT 36 AS SHOWN F = W.D.
W.D. = D - .6
W.D. = D - .6
DIVIDE INTO 5 EQUAL PARTS 2 ND. PART = W.D.
BISECT OVAL AS SHOWN J = W.D.
BISECT OVAL AS SHOWN J = W.D.
W.D. = D - (.33 .6 + 1 75%)
W.D. = D - .6

FIGURE 1

horizontal to the near vertical, on different roll diameters, each with a different peripheral speed, to a bar with variable temperatures whose speed is constant, the multiplicity of variables is increased to the point wherein we use more judgment than mathematics in applying reductions of area over the different surfaces of the profile.

While this deformation in reducing steel to the required shape goes on, there is an intense friction set up between the bar being rolled and the pass in the rolls.

In addition to the friction and consequent roll wear caused by a bar being delivered at a constant speed from varying diameters, each of these diameters have three additional frictional movements which produce wear, namely:

(1) Slippage, due to the entering bar traveling slower than the surface, or peripheral, speed of the rolls. (2) Forward slippage, due to the bar leaving the rolls at a higher speed than the surface speed of the rolls. (3) Spread, which is a lateral movement on all sections except plates, wide flats, sheets, tinplate, strip, etc.

The part of the bar which is under draft during its passage through a pass is called the projected contact area. Let us examine this with the aid of the accompanying sketches. (Figures 2 and 2a.)

If we analyze the area under draft from the angle of contact to the delivery point of the bar we find many interesting things and many forces at work; for it is between these two points that the metal is conformed to the proper shape; pass wear takes place; also, where good steel is, many times, converted into defective steel.

When the bar first comes in contact with a properly designed pass, the first action of the rolls is to draw the bar into the pass. At the same time, the cross sectional area is reduced to conform to the pass, finally emerging from the exit side in the required shape.

FIGURE 2

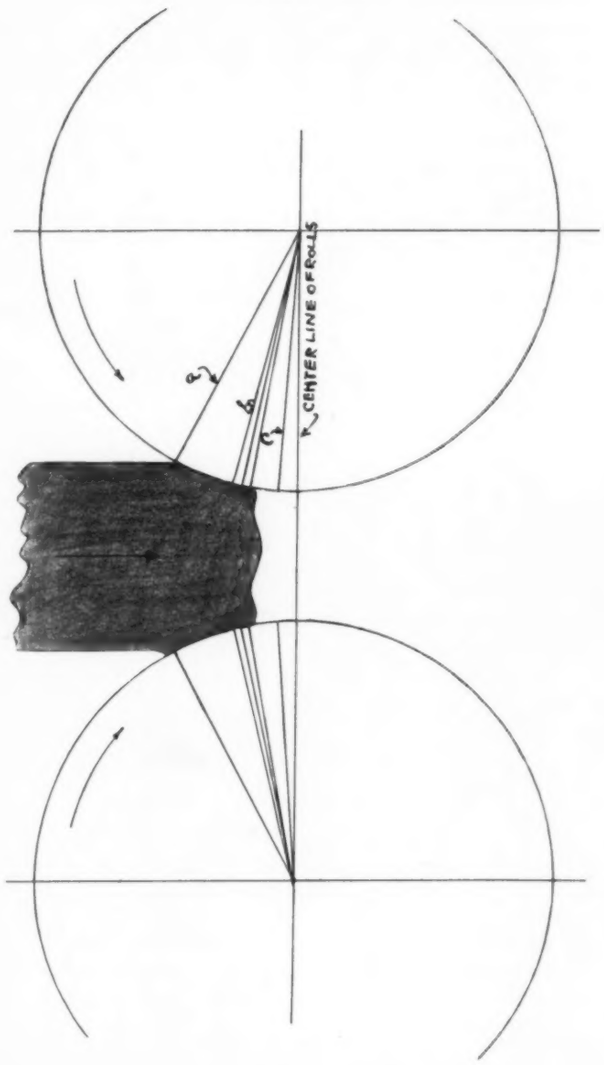
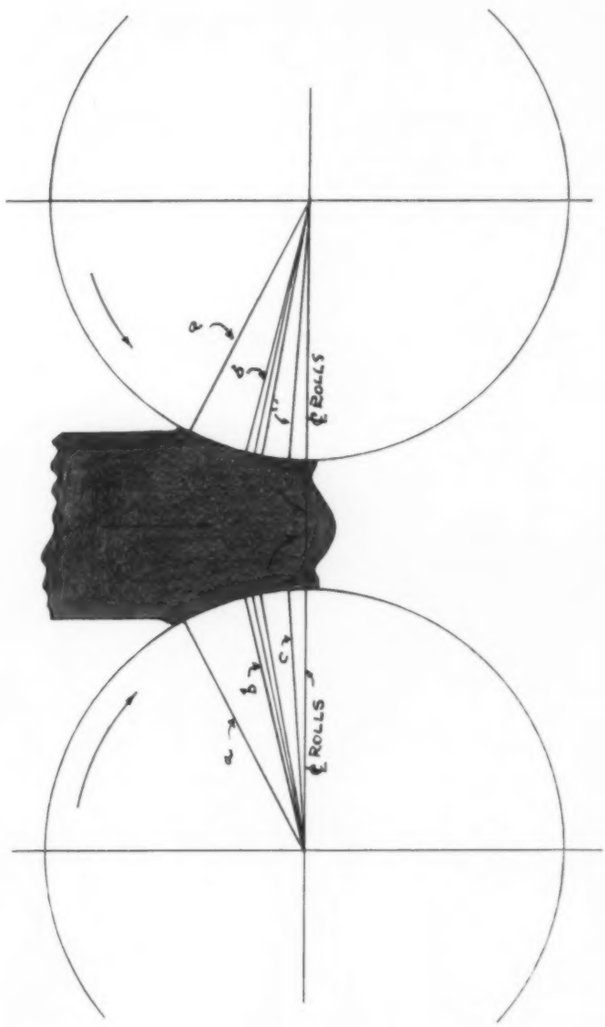


FIGURE 2 A



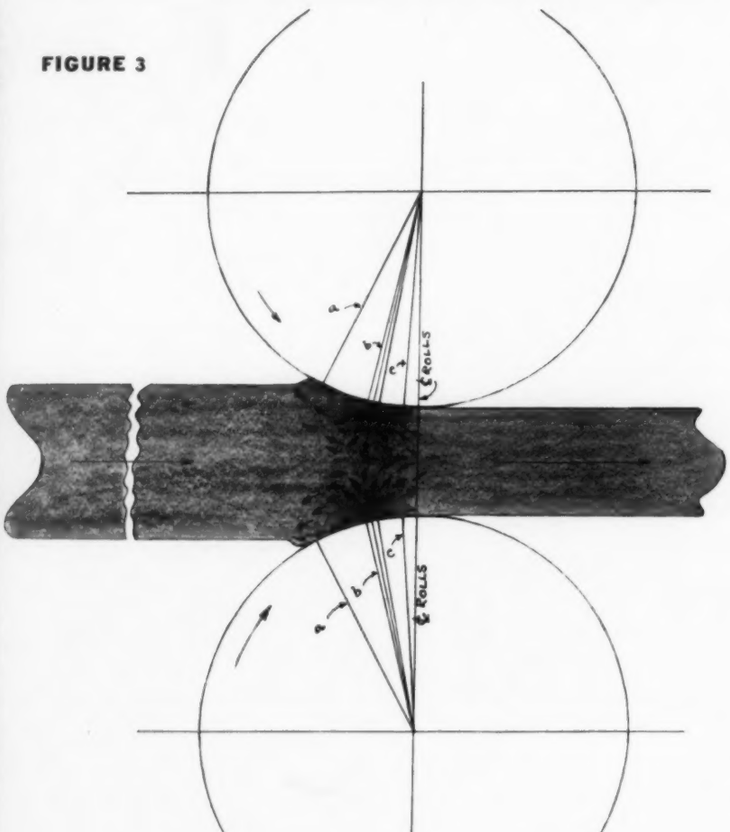
This all sounds very simple, and, to the layman watching the bar being rolled, it looks just as simple. Such is not the case, however. When the bar enters the pass at (a), (Figure 2) the angle of contact, one of the first actions which takes place, in addition to a vertical reduction, is spread. When the bar reaches a point at approximately (b) (Figure 2) on the chart, a slight bulge starts to form in the center of the front end of the bar. At approximately this same time, a slowing up of the bar on the entry side takes place. This bulging of the front end and retarding of the entering part of the bar would lead us to believe that some force is forcing the front end of the bar to bulge, while this same force acting in the opposite direction is retarding the bar, which now travels at a slower speed than the roll surface speed.

As the bar travels through to (c) Figure 2, the bulge is more pronounced. Between (c) Figure 2a and the vertical center line of the rolls, (the slip point), the bar is traveling faster than the surface speed of the rolls.

We believe that herein lies the story of the flow of metal which we describe on the next sketch. (Figure 3.)

When the bar reaches some point near (b), most of the reduction has taken place. The compression causing this reduction, and consequent flow of metal, causes a piling up of the same which may be likened to the action of a blunt wedge being forced into the bar.

FIGURE 3



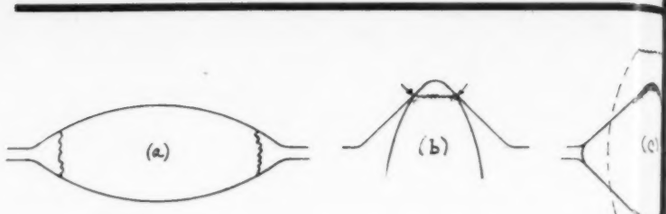


FIGURE 4

The action at (b), or the blunt apex of the wedge, is at right angles to the pass surface. At this approximate point, the bar is going at the same speed as the rolls. As this is a simulated wedge action, the areas on either side of (b), under the surface and extending to some depth, (depending on the diameter of the rolls), are traveling in opposite directions. The forces toward the entry side find the easiest escapement backward and toward the surfaces of the incoming bar, being dissipated by retarding the speed of same. A slight bulge may be noted at the angle of contact (a), particularly if the draft is heavy.

The forces toward the exit or delivery side have a harder time escaping due to being forced into a smaller space toward the exit point. The line of least resistance is, therefore, through the softer center of the bar, which extruding effect causes same to bulge. This extrusion force is so great, and at a speed faster than the roll surface speed, that it causes forward slippage just before the narrowest point between the rolls is reached. The result is that the last part of the rolling done between (c) and the center line of the rolls is really a forced die action. This action is more noticeable on cold steel than on hot steel, as the rolls have less grip on the bar. Also, the tie-in between the extruding center and the outside of the bar is greater when the steel is colder and harder.

It is this slippage, both backward and forward, and laterally due to spread, which causes roll wear.

Herein lies the problem of the roll manufacturer. He must give you, the operator, a roll which will grip the bar, take it on its course through the pass with the least possible injury to the steel being rolled, and at the same time have sufficient inherent lubricating qualities in its make-up, in addition to the finest alloys and workmanship, to withstand the enormous friction and pressures to which it is subjected and thus resist wear and breakage.

Additional methods can be used which will aid materially in reducing roll wear. The use of grease or oil on the passes will be found very beneficial in reducing wear and scale pick-up.

Proper water control, whereby excess water is prevented from being trapped between the bar and the rolls on sections such as rails, beams, channels, etc., is also beneficial.

Water thus trapped and entering in a pocket between the bar and the rolls is almost instantaneously converted into steam at enormous pressures and will

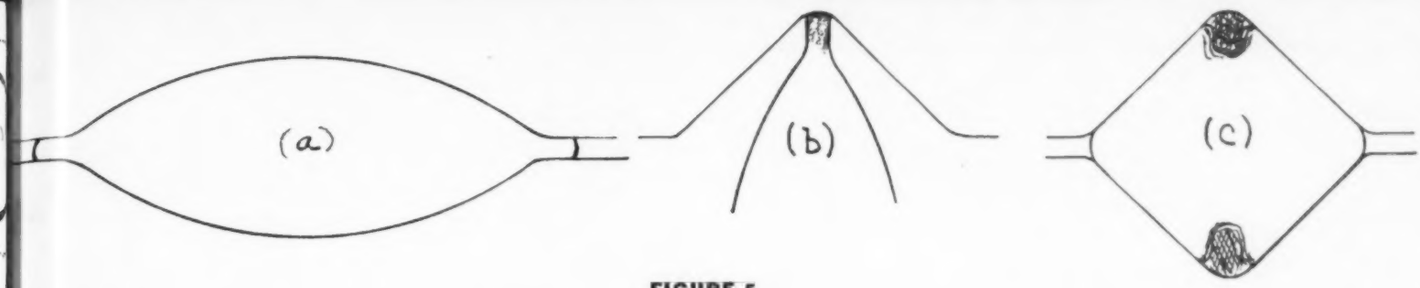


FIGURE 5

escape by cutting its way out to the detriment of both rolls and the steel being rolled.

Many rough surfaces on sections which are blamed on rough rolls are really caused by steam pressure thus generated.

The use on rolls of oil, grease, and tar, or a combination of these lubricants, has been in practice for years in some mills. A combination of oil and tar was used in the Rail Mills in Germany as far back as 1912.

One very good adaptation for rail mill use on edgers and leaders was developed about 1913 by the late Charles E. Duncan. It served the double purpose of preventing excess water from entering the pass with the bar and at the same time lubricating the pass with grease and oil mix.

In small mills, heavy grease or a piece of suet is held against the pass. The use of oil or grease has also been used many times as an aid in the prevention of "collaring".

I would like to take a short time to analyze three different methods of rolling plain bars, namely: The conventional diamond to square; oval to square; and the so-called diagonal or compression method, wherein a bastard square is introduced into a bastard square.

We believe that the first of these methods to be used was the diamond to square, wherein diamonds of proper thickness and width were turned 90 degrees before being edged (or upset) in a square pass.

It was found that while the diamond pass gave very good quality, heavy reductions were limited on thin wide diamonds by a high angle of contact and resulting spread, inasmuch as the large square should be entered into the diamond pass on the corner. Further, if a diamond be too shallow in proportion to its width, the square will not ride through on the corner but will, instead, roll over on the flat, wherein the pass will be badly underfilled on all corners.

The oval pass was later developed and proved by far to be the best elongating pass for heavy reductions. In the oval to square method, the square is introduced into the oval with the face of the square up. This should not be confused with some types of rod mill, wherein a so-called "high" or "empty" square is entered into the following oval "empty" side up, or, on the diagonal. This gives good oval width control, but reductions are necessarily light.

The oval to square method permits such high reductions that we often wonder if this is not over-done.

Most designers claim better quality from the diamond to square than from the oval to square, while others claim they see little difference and use the oval to square as the cheaper method of reduction.

We believe that both good and poor quality materials can be produced by either method.

The last to be mentioned is the diagonal or compression method.

The theory of this method, wherein a square is introduced into a square, is that all faces of the entering bar are in quicker contact with the enclosed pass faces than by either of the other methods. Spread is supposed to be restricted by this method.

One very important thing is noticeable, however, in that reductions are moderate. But, is it not true that light reductions and quality go hand in hand–

We mention properly filled passes. In this matter, we place as much responsibility on the roller in the mill as on the designer of the roll passes.

We must all admit that ingots have inherent surface defects which have not, to date, been eliminated. Granting, however, that an ingot with the best possible surface obtainable is cast, reheated, bloomed under the best possible conditions and practice, both as to heating and reductions, and is later reduced to a billet of the best quality, allowed to cool, is inspected and all original surface defects removed by chipping, we would naturally think that in the further reheating and reduction of the billet to a finished bar we should have a product free from seams—providing, of course, that there are no overfills or other defects such as produced by rough rolls or ragging. Such is not always the case, however.

We believe that there are times when an under-filled pass is just as dangerous as an over-filled pass in affecting seams and laps, and we here present one of the reasons on this sketch. (Figure 4.)

If the width of the point or open sided portion of the oval has a radius or blunt point larger than the fillet of the square pass to which it is entered, there is always danger of a pinching action on the point of the oval by the inclined sides of the square pass, which pinch would close together any irregularities present at the oval ends, thus forming seams.

On the other hand, if an oval is over-filled (Figure 5) and granting that there is sufficient thickness of stock in the over-filled portion for clean upsetting, or edging, without a lap, the fact that this thin edge is in contact with the colder atmosphere, cooling from water and

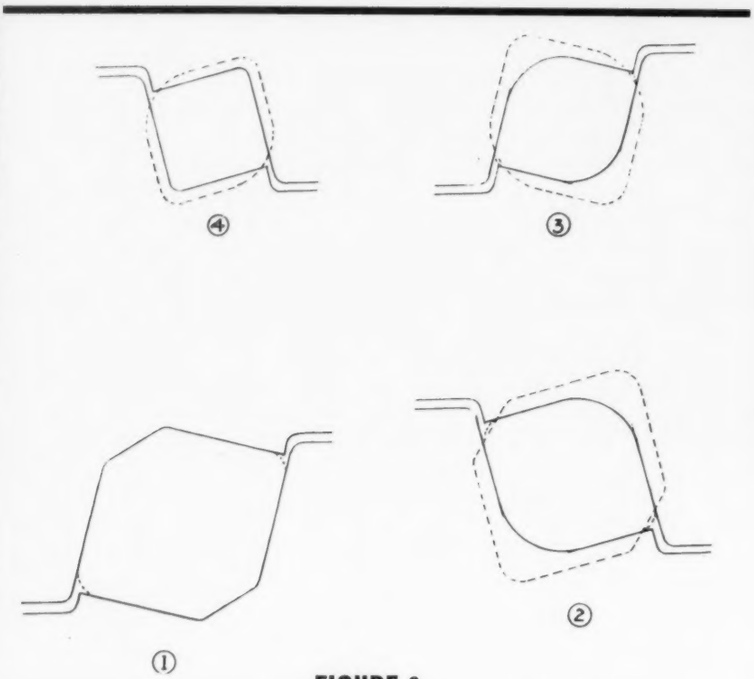


FIGURE 6

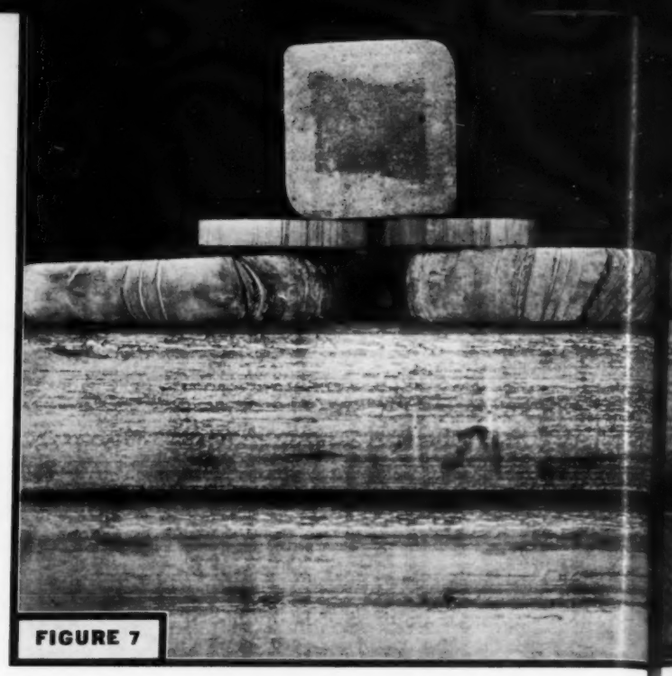


FIGURE 7

roll contact, it is liable to cause production of a faulty bar through poor grain structure and strain in that the cold over-fill, while it may not lap, will embed itself into the bar as per sketch (c) in Figure 5.

The same can also happen in diamond to square rolling.

It will be seen from the foregoing that properly filled ovals to squares and diamonds to squares rolled on smooth surfaced passes are essential if a high quality product is to be produced.

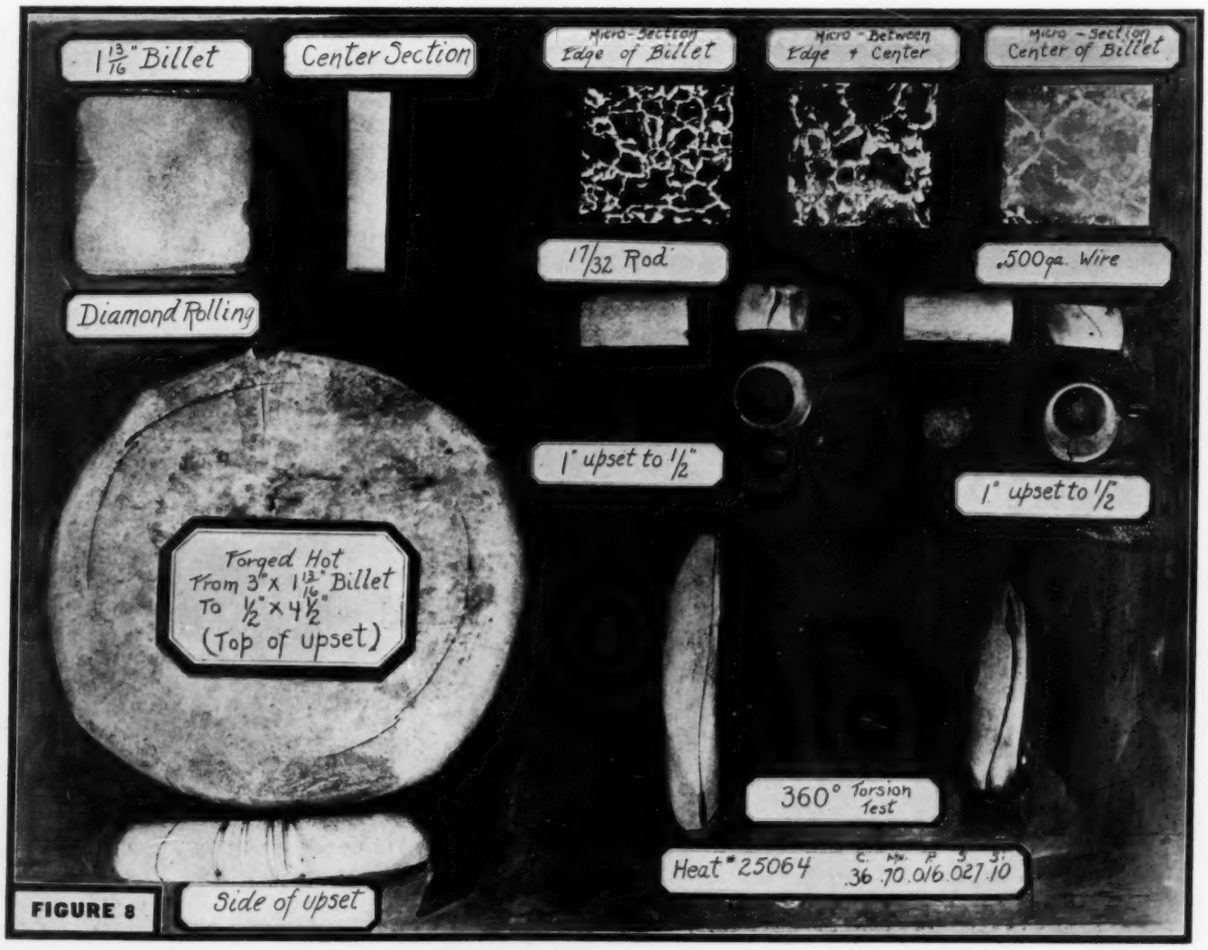

1 13/16" Billet
Center Section
Micro-Section Edge of Billet
Micro - Between Edge & Center
Micro - Section Center of Billet
17/32 Rod
.500 ga. Wire
Diamond Rolling
1" upset to 1/2"
1" upset to 1/2"
Forged Hot From 3" x 1 13/16" Billet To 1/2" x 4 1/2" (Top of upset)
360° Torsion Test
Heat # 25064 C .36 Mn .70 P .016 S .027 Si .10
Side of upset

FIGURE 8

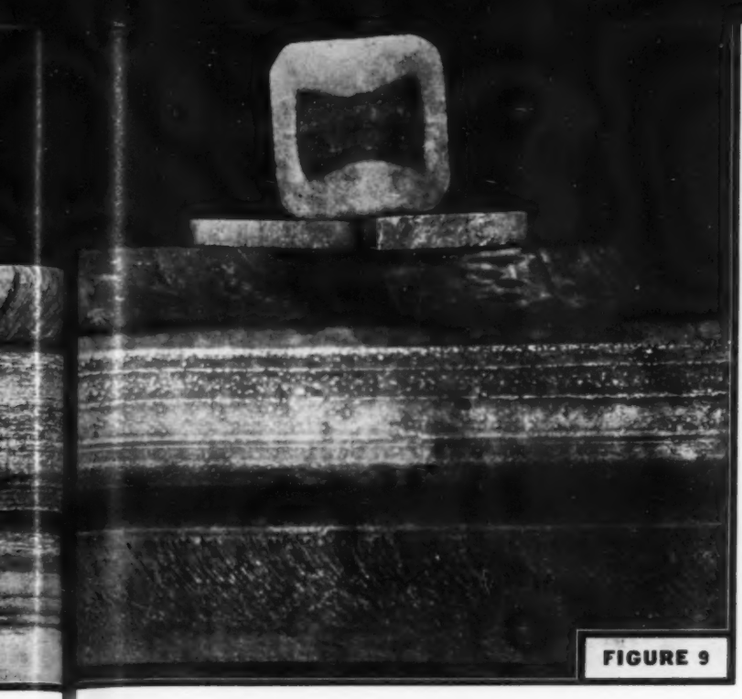


FIGURE 9

Rolling by the diagonal or compression method may be new to some, so we present Figure 6 showing passes designed for the production of billets on a continuous billet mill.

We believe a comparison of the two methods, diamonds and ovals to square versus the compression or diagonal method, would be interesting, and we present it on the following illustrations.

Figure 7 shows the surface, cross section and up-set test pieces of a billet rolled by the diamond to square method. Following this through, Figure 8 shows various sections from the billet to the finished rod with respective up-set tests and photomicrographs. It will be noted that flaws present in the billet persist through to the finished rod.

Figures 9 and 10 show the surface, cross section and upset test pieces rolled by the diagonal method, the freedom from seams and laps being particularly noticeable. The material down to the finished rod (Figure 10) shows the beneficial results of having a clean billet at the start.

We do not say that the flaws present in the diamond and oval to square method are a true picture of quality at all plants but show those existing at the particular plant where these pictures were taken. The steel used in both cases was of the same quality up to the point of diagonal or compression rolling.

It should be understood that in presenting these cuts we are not sponsoring any particular method of rolling. We believe that both good and poor quality material can be produced by either method. We do, however, once again stress the value of light reductions as related to quality. The comparisons, are therefore, presented solely for their informative and interest value.

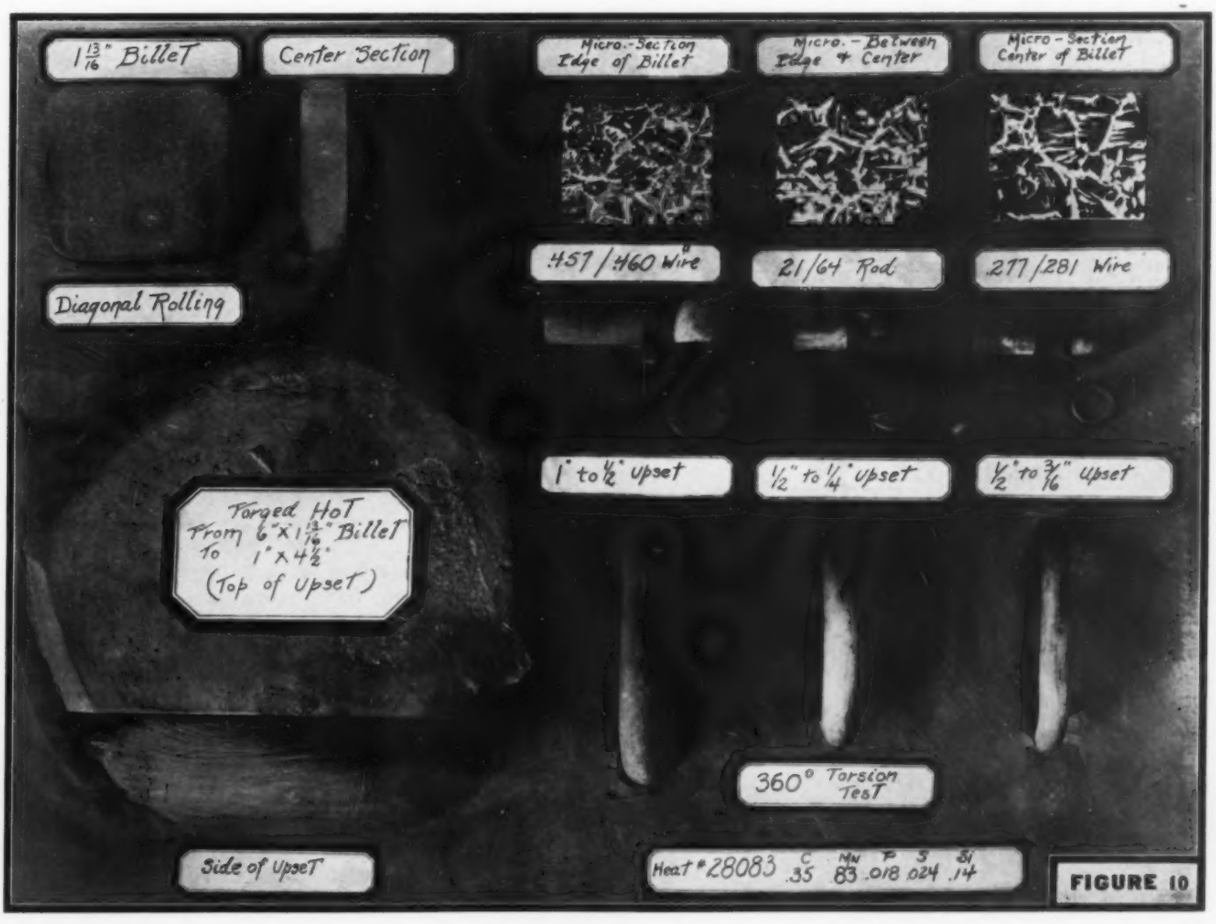

1 13/16" Billet
Center Section
Micro.-Section Edge of Billet
Micro.-Between Edge & Center
Micro-Section Center of Billet
.457/.460 Wire
21/64 Rod
.277/.281 Wire
Diagonal Rolling
1" to 1/2" Upset
1/2" to 1/4" Upset
1/2" to 3/16" Upset
Forged Hot From 6"X1 13/16" Billet To 1"X4 1/2" (Top of Upset)
360° Torsion Test
Side of Upset
Heat #28083 C .35 MN .83 P .018 S .024 Si .14

FIGURE 10

LUBRICATION of Morgoil Roll Neck Bearings

By H. H. WOOD, Engineer
Morgan Construction Company
PITTSBURGH, PA.

Presented before the A. I. & S. E. Annual Convention, Chicago, Ill., Sept. 28, 29, 30, Oct. 1, 1937.

▲ THE Morgoil Bearing is a totally enclosed oil film bearing whose inner and outer races are separated by an unbroken oil film. It was developed primarily for use on roll necks in rolling mills where, due to its high load carrying capacity and freedom from fatigue and wear, it has quickly made a place for itself, not only in the ferrous and non-ferrous mills in this country, but in foreign countries as well. These bearings have been built for rolls of nominal body diameters as small as 9″ and as large as 56″. The continuous full load capacity of the bearing for 9″ roll is 100,000 pounds each and for the 56″ roll, 5,250,000 pounds each. In the steel industry these bearings have been applied successfully to rod, merchant, alloy bar, sheet bar and billet mills and to 2 Hi Hot and Cold Strip Mills as well as 4 Hi hot and cold strip mills. In the non-ferrous industry bearings have already been successfully applied to both 2 Hi and 4 Hi cold mills. Particularly interesting applications have been made to 2 Hi reversing hot mills and 4 Hi reversing cold mills.

DESCRIPTION OF THE MORGOIL BEARING

In order to discuss the lubrication of Morgoil bearings the elements which make up the bearing should be understood. (See Figure 1.) The bearing parts proper consist of the roll neck sleeve or inner race with taper bore and cylindrical outside surface and with integral thrust flange. This sleeve is keyed to the roll neck (to prevent relative rotation) by a comparatively short but husky key staked into the neck near the outboard end of the bearing. The sleeve rotates with the roll neck inside a steel bushing whose inner surface is coated with a comparatively thin lining of special bearing metal and the sleeve and bushing are separated by the oil film. The thrust bearing, which is double acting, consists of the thrust flange on the sleeve, or the rotating element, and two stationary steel thrust shoes with the surfaces adjacent to the flange of the sleeve also coated with a comparatively thin section of the same special bearing metal used in the bushing. The double acting thrust bearing is adjustable for the required running clearance by means of a thrust adjusting ring threaded on to a projection from the inside of the cover plate of the chock enclosing the bearing. The taper bore roll neck sleeve, whose taper is non-locking, is held in position on the roll neck by a lock nut threaded over a split threaded ring which seats in a wide groove in the roll neck. The nut is locked in correct position and prevented from backing off by the application of a vernier key at the outboard end and this key, which is loose fitted, is held in position by a spring retainer.

H. H. WOOD

Oil is retained in the bearing by seals of a conventional type at both inboard and outboard ends. The inboard seal is a double seal whose element toward the roll barrel is used to prevent entrance of foreign matter to the bearings. As a further guard against entrance of foreign matter, a ring of self lubricating bronze is held against the end of the roll barrel under light spring pressure and water and other foreign matter is prevented from by-passing around this ring by a waterproof flexible leather boot, as shown in the cross section.

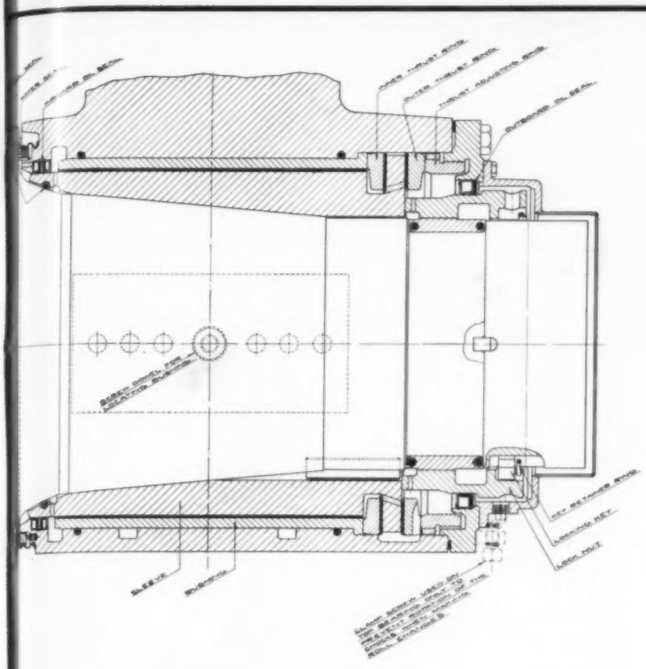


Figure 1—Cross section of Morgoil bearing mounted on roll neck.

On mills where water sprays are used it is usual to install inboard water guards made of sheet metal to break up the sprays and prevent them from impinging on the bronze ring of the water seal assembly.

It is apparent from the assembly of the bearing, that it can be removed from the roll neck as a unit by removing the lock nut, and assemblies of this type are highly desirable when it is necessary to change bearings from one roll to another.

OPERATING CHARACTERISTICS

The Morgoil bearing has a very low co-efficient of friction in the range of .0012 to .003, which is on a par with the co-efficient of friction of anti-friction bearings, oil or grease lubricated. The roll neck sleeve is alloy steel and is hardened to secure the best possible grain structure for surface finish. The illustration, Figure 2, shows the mirror finish of the roll neck sleeve.

It is important to have the best possible finish on the surface of the special bearing metal in the bore of the bushing and this is obtained by a diamond boring operation with a very high speed and small feed. It is obvious that with almost perfect surfaces of journal and sleeve the oil film can be extremely thin and still prevent metal to metal contact. This results in uniformity of load carrying capacity throughout the speed range of a mill.

METHOD OF LUBRICATION

The oil enters the bearing through a drilled hole parallel to the axis of the roll and at any convenient location in the chock. (See Figure 3.) The drilled hole meets two annular grooves in the bore of the chock extending over 180° around the bore. Horizontal branches from these annular grooves on the horizontal center line of the bearing on each side of the bore of the chock carry the oil to holes in the side of the bushing through which the oil flows to oil pockets in the bore of the bushing, one on each side centered on the horizontal center line. These oil pockets are eccentric rebores which extend almost to the inboard and outboard ends of the bushings. From these oil pockets, which are kept full of oil under slight pressure, the bearing receives its oil supply, the sleeve acting like the rotor of a pump and pulling a wedge shaped film of oil into the load zone of the bearing. As there is an oil pocket on each side, it does not make any difference which way the bearing runs. It can start and run either clockwise or counter clockwise and, therefore, the bearing is applicable to either straight-away or reversing mills.

No effort is made to trap the oil in the bearing parts proper. The end leakage from the inboard end drains to the inboard oil sump in the chock. The end leakage from the outboard end flows into and lubricates the double acting thrust bearing. A series of drilled holes at an angle in the thrust flange carry the required amount of oil to the outboard element of the double acting thrust bearing and from both sides of the thrust bearing the oil drains to the outboard oil sump. As will be seen, the inboard and outboard oil sumps are connected by a large horizontal drilled drain and from this drain, which reaches the outboard surface of the chock, the oil flows to the flexible drain hose and so through the drain lines to the receiving tank of the circulating system.

A gasket at the inboard end of the roll neck sleeve prevents escape of oil along the surface of the roll neck at the inboard end. At the outboard end, the seepage of oil along the roll neck is interrupted by a groove with drain holes which carries any surplus oil to the outboard oil sump.

LUBRICANT RECOMMENDATIONS

The lubricant supplied to Morgoil roll neck bearings must be a high grade straight mineral oil free from acid and other impurities and must have a high resistance to oxidation and to the formation of sludge when subjected to hard service. It must separate rapidly from water and other liquid impurities and must, therefore, be a type of oil which shows an excellent demulsibility test. The above characteristics are important in that, in rolling mill service there is always a chance, no matter how adequate the sealing arrangements, that water may find its way into a bearing because of damage to a seal.

It is also of great importance that the oil be of a type which has a high viscosity index. In the lubrication system provision is made to control the temperature of oil, but necessarily there will be some variation and if an oil has a good viscosity index, it will not drop off as fast in viscosity with increased temperature as is the case with an oil of poor viscosity index.

The viscosity of the oil to be used in the lubrication system is determined by the minimum speed of operation of the rolls in R.P.M. and also by consideration

Figure 2—Roll neck sleeve and bushing showing, respectively, external and internal finish.

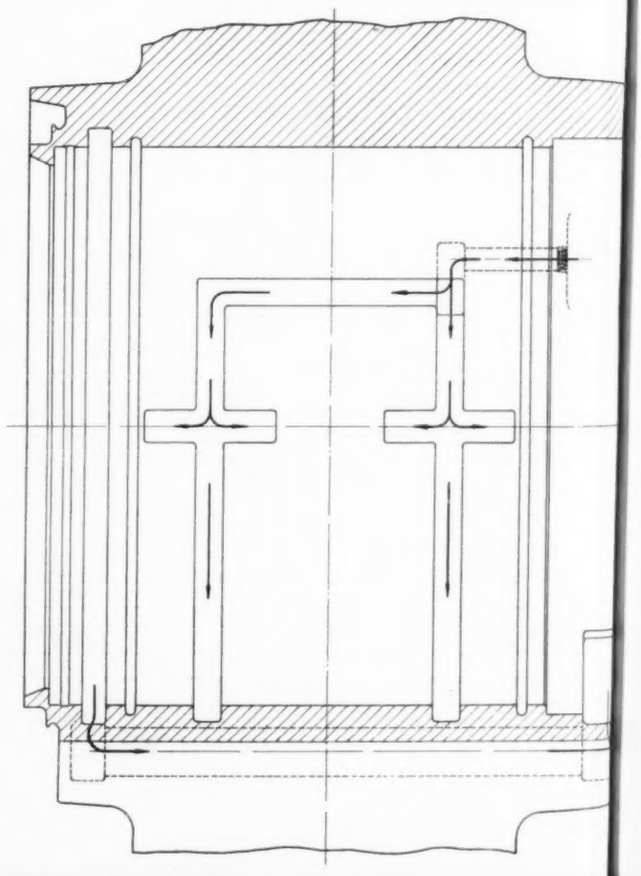
of the unit loading on the projected area of the bearing. If we assume that the bearing is loaded to its rated capacity of 3,000 pounds per square inch, the following tabulation gives required minimum viscosity with corresponding minimum R.P.M. for continuous load carrying capacity.

Minimum R.P.M.	Corresponding Minimum Viscosity S.S.U. Required for Morgoil Bearings at Full Rated Load
11	2400
12	2200
15	1800
18	1500
23	1200
31	900
37	750
53	500

A condition of maximum load, minimum speed and minimum viscosity of oil that will support the load makes for lowest possible co-efficient of friction. As an illustration of viscosity selection, we will consider a large 4 Hi Hot Strip Mill. These jobs usually work out in such a way that the viscosity requirement in the slowest speed roughing stand is 2300 to 2400 seconds Saybolt Universal. Therefore, an oil having that viscosity at 100° F. is usually selected and, as it is necessary to maintain that viscosity within a rather close range, the temperature of the oil should be between 90° and 105° F. at all times. Therefore, the lubrication system is equipped with heating coils in the receiving tank which keep the oil at the correct temperature in cold weather, while an oil cooler is used in the supply line to the stands at the roughing end of the mill to keep the oil temperature in the range in hot weather. As the mill speeds increase through a continuous strip mill, we finally come to a stand, usually the third finisher, where the minimum speed is such that no cooling of the oil is needed in summer, for even though the viscosity is materially decreased, it is still sufficient to support the load at the lowest operating speed.

The quantity of oil required to lubricate the bearing is based on complete replacement of the oil film in a specified number of revolutions. This means that a given size bearing operating at high speed needs more oil than the same size bearing operating at low speed. Oil factors have been developed for each size bearing which, when multiplied by maximum R.P.M. of the roll to which the bearing is applied, give the maximum gallons per minute of oil required. The basis on which the oil factors are figured is partly theoretical and partly empirical and the use of the oil factors always results in an over-supply of oil, or what is termed "flood lubrication". This type of lubrication not only gives the bearing an adequate oil supply but keeps it clean and results in uniform bearing temperature and neck temperature which are highly desirable in rolling accurate products.

Figure 3—Cross section of chock showing oil passages and sump



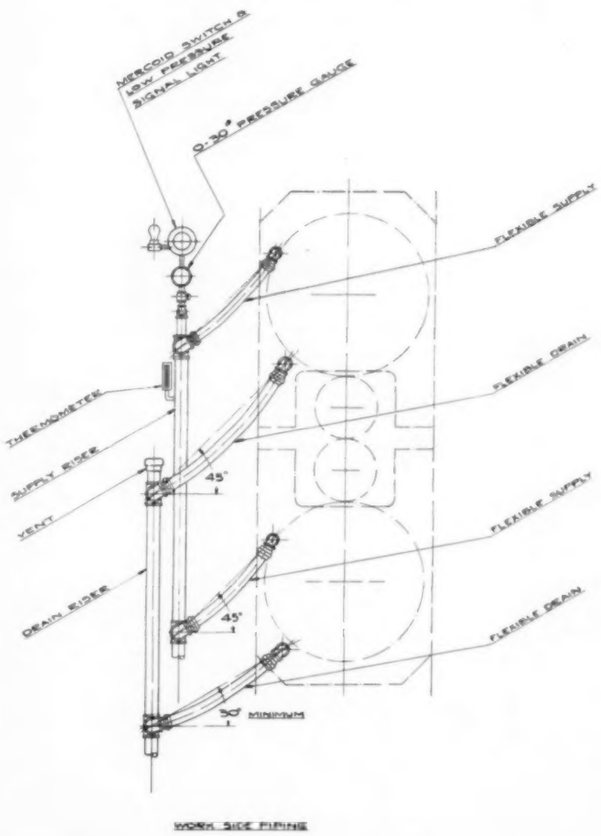
HOUSING PIPING

Figure 4 shows typical oil piping at the housing on a Morgoil-equipped 4 Hi Mill. On the drive side and also on the operating side of the mill stands, there is a supply riser and a drain riser. From the supply riser two flexible supply lines take the oil to the lubricant entrance in the top and bottom bearings. These lines are under pressure. From the bottom of each bearing at the drain opening, a flexible drain line takes the oil from the bearing to the drain riser. The illustration shows, on the supply riser, a thermometer whose bulb enters the stream of oil entering the bearing. From this thermometer the mill operator knows definitely the temperature of oil entering the bearings at all times. At the top of the supply riser is a pressure gauge which enables the operator to know definitely that the oil is being supplied to the bearings at the correct pressure. Also, at the top of the supply riser there is a pressure switch with low limit alarm and a red light. Low limit is set at a pressure below the normal operating pressure at the particular mill stand and if the pressure drops below standard the red light lights, signalling the operator, and usually the red light circuit is tied in to actuate a siren. In a multi-stand mill, the lighting of any red light will sound the siren and then by looking down the line of stands an operator can tell just where the pressure is low and make the necessary investigation and correction.

Both flexible supply and drain lines from the risers to the bearings are sloped so that when a mill is shut down for roll change and the oil feed is cut off, the oil can be drained out of these flexible lines to prevent oil loss when disconnection is made at the bearing.

Sufficient pressure is carried on the riser at the mill stand to cause the required gallons per minute of oil to flow through the bearings when the mill is operating at absolute top speed. At any speed below the maximum, the bearing acts somewhat as a measuring valve to the extent that it actually takes less oil when running at slower speeds. At half speed a bearing may take sixty or seventy percent of the oil that it does at top speed. When the mill slows down the pressure tends to rise, but this is limited by pressure regulating devices in the supply lines which prevent any appreciable fluctuation of pressure. At the point where flexible supply line is connected to the chock, nozzles are used to determine the amount of oil which will flow into the bearing, the flow being governed by pressure on the supply line ahead of the nozzle. Pressures used in the supply risers and flexible supply lines are usually from 5 to 15 pounds per square inch.

Figure 4—Typical housing piping for a 4-Hi mill.

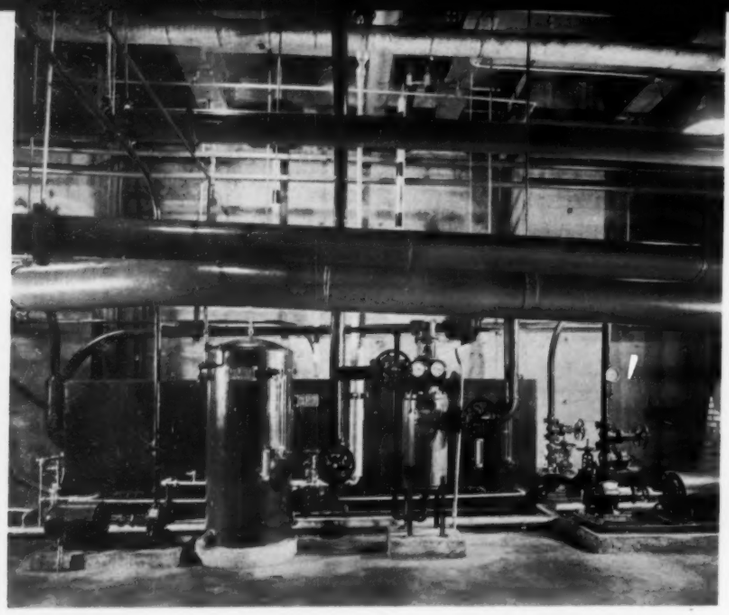


CIRCULATING SYSTEM

Lubrication system equipment required in the circulating system serving a Morgoil bearing installation varies, of course, with different types of mill installations. In general, the equipment consists of a single or double compartment receiving tank in the oil cellar from which rotary oil pumps, motor driven, take the oil through a floating suction. Two pumps are installed, either of which is adequate to supply the maximum amount of lubricant required. One pump delivers one hundred precent of the oil through filters of the mesh type or of the rotary self-cleaning type, and from the filters the oil goes into the main supply line and so to the mill. Beyond the filter there is a lead from the main supply line to a pressure tank. Compressed air is introduced to the top of the pressure tank so that the tank is normally about half to two-thirds full of oil. A pipe leads off horizontally from a location near the top of the pressure tank and on the pipe and connected into it are three pressure switches. Two of the pressure switches are for the purpose of starting and stopping the service pump and the spare pump and are adjustable throughout a given pressure range. The third adjustable pressure switch is used to ring an alarm gong if, for any reason, pressure on the main supply line is below standard.

These lubrication systems are usually operated with one pump running continuously. As the pump delivers a definite number of gallons per minute and as the demand at the mill varies with the changes in speed and with starting and stopping, a relief valve is provided in the main supply line in the vicinity of the pressure tank branch and is adjusted to give the desired main supply line pressure. It spills surplus oil back to the receiving tank.

Under some conditions, for instance, in a large cold mill department, where a large central lubrication



Courtesy De Laval Separator Co.

Figure 5—View of oil cellar showing pressure tank, rotary filter, receiving tank and pumps.

system is provided to serve many different groups of mills, it is sometimes desirable to operate the system on the "stop-start" basis. The pressure tank is of large capacity and the pressure switches controlling the pump are adjusted in such a way that the main service pump, while running tends to build up the pressure to a predetermined limit. At this limit the pressure switch operates and shuts the pump down. Due to the large capacity of the pressure tank in comparison to the G.P.M. requirement at the mill, the drop in level of oil in the pressure tank is comparatively slow and when the level has fallen with corresponding pressure drop to a predetermined limit, the main service pump is again cut in by pressure switch and the cycle is repeated. With this type of system operation is very satisfactory even though the demand for oil in the department is as low as five or ten percent of the capacity of the system.

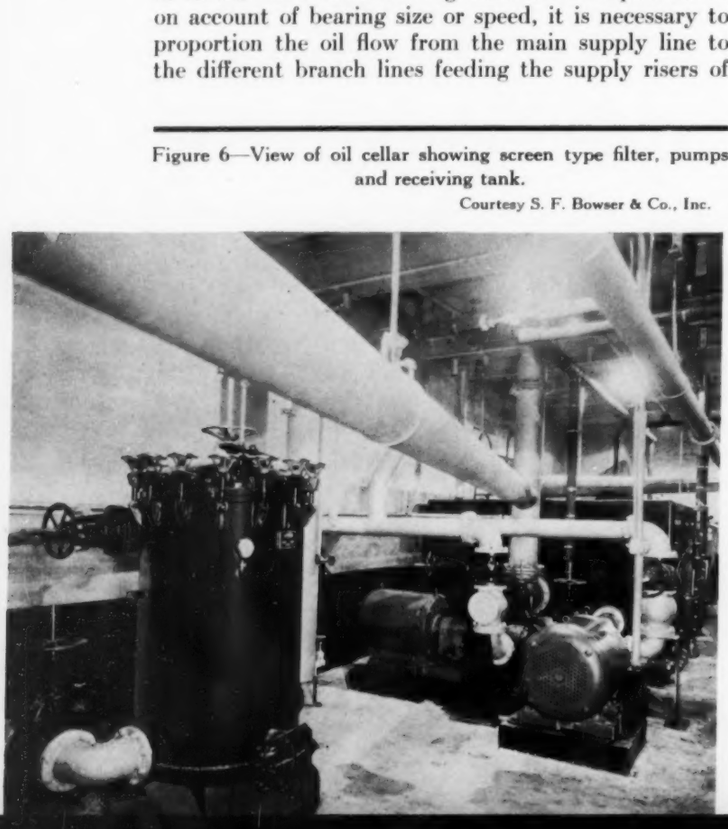
Where one circulating system serves Morgoil bearings in various mill stands having different oil requirements on account of bearing size or speed, it is necessary to proportion the oil flow from the main supply line to the different branch lines feeding the supply risers of the stands. This is accomplished by the use of calibrating nozzles in the supply lines at point of entrance to the bearings and desired pressure ahead of the nozzle is obtained by pressure reducing and regulating valves where necessary.

When it is necessary to use oil of high viscosity, which is usually the case in large strip mill jobs, it is desirable to use double compartment receiving tanks. Each compartment with its complement of oil has sufficient capacity to handle the job. While the oil from one compartment is being used in the circulating system, the oil in the other compartment is resting which gives it a chance to settle out impurities. Also, in large and important installations using high viscosity oil, it is good practice to install a centrifuge so that if impurities do not settle in the resting compartment even by raising the temperature of the oil by use o heating coils, it can be centrifuged and purified.

Figures 5 and 6 show typical installations of lubricating equipment in oil cellars for large strip mill jobs.

Figure 6—View of oil cellar showing screen type filter, pumps and receiving tank.

Courtesy S. F. Bowser & Co., Inc.



CONCLUSIONS

The following requirements for Morgoil Bearing Lubrication Systems merit consideration.

1. A high quality straight mineral oil meeting standard Morgoil specifications.
2. An adequately proportioned lubrication system of the full filtration type, automatic in operation and equipped with standard pressure and temperature controls and protective alarm.
3. Thorough cleaning of the lubrication system before introduction of the lubricating oil at the time of starting the installation.
4. Maintaining an adequate amount of oil in the system at all times during the operation so that there will be a proper relation between the amount of oil being pumped and the amount of oil in the receiving tank.
5. Periodic tests of the oil in the system for viscosity, neutralization value and contamination. If the operating company is not equipped for such laboratory tests, the supplier of the oil in most cases is glad to make them.

In conclusion, varied installations of these bearings on roll necks have proven that the oil film separating the sleeve and the bushing has a tremendous load carrying capacity. The oil is not subject to compressive fatigue and neither are the bearing parts because the load is spread over a large surface and the stresses in the various parts of the bearing are very much below the fatigue point. The design of the bearing is such that the oil film is maintained which results in absence of wear. Therefore, the ultimate life of these bearings if properly lubricated and maintained, is indefinite and maintenance costs per ton of product are lower than in any other type of bearing. The successful operation of the bearings is predicated on an adequate and constant oil supply and this has been made possible through the cooperation and interest of the manufacturers of circulating system equipment and the oil companies who can supply the type of oil specified for this service.

DISCUSSION

PRESENTED BY

W. E. HAMILTON, Lubricating Engineer, Tennessee, Coal, Iron and Railroad Company, Ensley, Alabama.

L. F. COFFIN, Superintendent, Mechanical Department, Bethlehem Steel Company, Sparrows Point, Maryland.

G. S. WARREN, Chief Engineer, Sharon Steel Corporation, Sharon, Pennsylvania.

H. A. SMITH, Socony-Vacuum Oil Company, Pittsburgh, Pennsylvania.

H. H. WOOD, Engineer, Morgan Construction Company, Pittsburgh, Pennsylvania.

W. E. HAMILTON: Will Mr. Wood please state the approximate water content that can be carried in the circulating oil without danger. In other words, at what percentage of water content should action be taken to remove the water?

L. F. COFFIN: It may be of interest to know that there are some installations of bearings of a similar type, fed from a central lubricating system in which the return oil from each stand passes through a sight-glass so that color of oil can be seen and it is thus possible quickly to locate and identify the particular stand that may be having water contamination.

I would like to ask Mr. Wood the approximate length of life that might be expected from seals on this type of oil lubricated bearing in the finishing stand of a rod mill.

G. S. WARREN: I want to thank Mr. Wood for a very interesting paper covering the Designs and "Lubrication of Oil Flooded Roll Neck Bearings", and I think we should also thank the Morgan Construction Company for the development and application of this type of bearings to both hot and cold roll mills. It is one of the greatest improvements in rolling mill equipment that has been made in several years, as it has made it possible to double the capacity of our old two-high hot and cold roll strip and bar mills, without increasing the capacity of the drives.

A fine proof of this statement is the Sharon Steel Corporation's 21″ 5 Stand Tandem Sheet Bar Mill. This mill is driven with a 4,000 H.P. motor. With the combination babbitt and brass bearings, we could not roll a full length bloom into an 8″ x ¼″ sheet bar, but would have to cut it into two pieces to avoid stalling the motor. After installing the Morgoil Bearings, we were able to roll a full length bloom into a 16″ x ¼″ sheet bar without stalling the motor. In other words we have more than doubled the capacity of the sheet bar mill by installing Morgoil Bearings.

There have been a number of improvements in the oiling systems for these bearings since we installed the original set in 1932 in our Hot Strip Mill at Sharon, but we are still running these bearings with a gravity system. In 1936, we made another installation of Morgoil Bearings on our Sheet Bar Mill at Lowellville that has the gravity oiling system. We have had very little trouble with these systems and have not lost any bearings due to the gravity system.

Recently we have installed Morgoil Bearings on several of our two-high Cold Roll Strip Mills, where we are rolling Stainless Steel, and we have been able to more than double the capacity of these mills. These bearings have the pressure oiling system, which without a doubt is safer than the gravity system.

The Sharon Steel Corporation was the pioneer in the operation of these bearings on rolling mills, and naturally expected that there would be some bugs that would have to be worked out. We have been agreeably surprosed as we have had no serious trouble, and the original bearings, installed in 1932, are still operating. They may have had some bushing renewals, but very few. We have abused these bearings with heavy overloads, broken rolls, and with oil that has contained considerable water, at times. This water taxed our oiling system to about the limit on several occasions, but due to the fact that we were using a very good grade of oil, we did not destroy the bearings.

Our only real trouble has been to get seals that would keep all the oil in, and all of the water out of these bearings. We are getting better, but there is still room for improvements in the seals.

H. A. SMITH: Speaking of water leaking into the lubricating system, and scale entering, with trouble from both, you might consider the intermediate result to find the real trouble is from an emulsion of these two with the oil. As you know, such an emulsion is a mechanical mixture of oil and water, plus solid impurities, resulting from their having been shaken up or otherwise blended together. Regardless of the percentage of water in the oil system, these two liquids are passing through the bearing—through the section of minimum clearance, which is measured in thousandths of an inch—and are broken up into small globules. The smaller the size of these globules, the more persistent becomes the emulsion and when we add to that, as a nucleus, any impurities such as scale dust, we make the mixture still more permanent. It is in this mayonnaise-like form that it is most harmful.

This material tends to clog the filters, valves, centrifuge bowls and smaller oil passages, as well as cause rusting or bad corrosion if the water is acid, particularly at any point where it might collect. Such an accumulation in the bearing clearances would not be likely to drain out when the mill was shut down, but rather remain to cause serious corrosion of the polished bearing surfaces,—time and acidity influencing the degree of action. To select an oil that will separate more readily from water, scale and other impurities, as well as having the desirable stability and other characteristics, is the problem and a very important factor.

As far as the neutralization number is concerned, we don't know exactly where the danger point is for an

oil in a circulation system. In both this country and in England, engineers have made various studies in attempts to set some limiting value for safe operation. After several years of experimenting, no one has yet been able to set a definite figure.

What you should rather watch is the rate of change in the neutralization number. If it increases slowly and gradually, you have very little probability of trouble; but if it goes up suddenly, you should be on guard because something is beginning to happen to the oil. As it may start serious oxidation and sludging at this point, you should analyze a representative sample from the system. Your oil supplier should be able and willing to do this for you, or to run a check test against your figures, if you desire it. To sum up, we do not believe there is any definite figure beyond which you can say the danger point lies and suggest comparisons of analyses of periodic samples.

H. H. WOOD: In answer to Mr. Hamilton's question I would say that the limit would be four percent. Many systems are operating with not to exceed one half of one percent moisture in the oil. We had one experience recently in a system where no particular care had been taken of the oil over a period of a year and a half and the moisture content had increased gradually until it was eighteen percent. In spite of this high moisture content there were no bearing failures. As soon as we learned of this condition our customer was advised to batch treat the oil by applying heat over a couple of week-ends with the result that the moisture content was brought down to one-half of one percent without centrifuging. Subsequently they have used more care in handling this lubrication system.

The following is my answer to question by Mr. Coffin:

I think you would probably get on an average a year's service out of the seals.

In Mr. George S. Warren's discussion he states that gravity oiling systems are used on MORGOIL Bearings in Sharon Steel Corporation's Hot Strip Mill and Sheet Bar Mill while on more recent cold mill installations pressure oiling systems are used. All of the lubrication systems, as a matter of fact, are what are termed "Pressure Systems", as the pressure in the supply lines to the mills is built up by the pumps and is not due to head from overhead tanks. In the two hot mills, the line pressure persists up to the regulating valve of sight feed oilers installed at each bearing. There is no pressure to speak of from the sight feed oilers to the flexible lines to the bearing proper. The flexible lines are therefore kept full of oil by the sight feed oilers and the bearings take the oil from the supply in the flexible lines. In their cold mill installations the line pressure is carried through the flexible lines to the oil supply entrance of the bearing. It is our feeling that the latter plan is the better one because there is some difficulty in properly regulating the flow of a sight feed oiler due to the variation in speed which exists in most mills.

As previously explained, lubricating oil for these bearings is selected on the basis of a viscosity sufficient to maintain an oil film at low speed operation in the slowest stand of a mill in order that the bearings in such a stand will safely carry their rated load. It is, therefore, necessary in the slow speed stand to keep the temperature of the oil being fed to the bearings within a range that we usually specify as 90 to 105°F. In the higher speed stands no particular supervision is needed as to oil temperature. In many cases the oil in summer time will reach a temperature of 130° in the high speed stand. At such a temperature the viscosity is only about forty percent of the viscosity at the normal temperature of 100° which should apply in the slow speed stands. However, if the speed is two and one-half times or more than two and one-half times the speed of the low speed stand on which the viscosity selection was based, the bearing will successfully carry its rated load. In this connection, the reason that we specify a minimum viscosity index is that we want to maintain viscosity at high temperature in a cerain relation to viscosity at a lower temperature. This relation must be definite if we are to select a minimum viscosity at the highest assumed temperature for summer conditions. It is necessary to know what the minimum viscosity will be in order to determine whether the bearings with that viscosity lubricant will carry their rated load at given high speeds.

Mr. H. A. Smith's remarks about formation of emulsion emphasize the necessity of maintaining water and oil seals properly so that they will efficiently keep water and scale out of the bearings and prevent loss of lubricant. He also properly emphasizes the desirability of working closely with the supplier of the oil by periodic testing of the lubricant to the end that maximum life will be obtained.

There is one very important point in the design of lubrication systems and that is the relation of the size of the receiving tank to the pump capacity. Each compartment in the receiving tank should have a capacity in gallons about forty to fifty times the gallon per minute capacity of the service pump. If this ratio is higher so much the better as the relation governs the resting time of the oil in the receiving tank and the more resting time the more chance there is for impurities to settle out.

Experience has shown that in the normal range of viscosities used it is impossible to centrifuge the oil in a resting compartment without raising the temperature. It is usual practice to raise the temperature of oil to 160° to 180° F. when centrifuging. It has been our experience that the lubrication systems designed normally operate without the use of a centrifuge. The oil specified has good demulsibility and by raising the temperature of the resting compartment over a week-end it is usual that whatever moisture has been picked up during the week's operation can be eliminated or at least reduced to a very low value.

COMBINATION FIRED BOILERS

at Carnegie-Illinois Steel Corporation

By C. H. WILLIAMS, Asst. Chief Engineer
Carnegie-Illinois Steel Corporation
YOUNGSTOWN, OHIO.

Presented before the Annual Convention of the A. I. & S. E., Chicago, Ill., Sept. 28, 29, 30, Oct. 1, 1937.

▲ THE Ohio Works is the iron and steel producing unit of the Youngstown District plants, supplying semi-finished steel to the McDonald Works and Union Works finishing mills, which normally consume its complete output in the form of slabs, billets and blooms for bar and strip products.

The iron and steel works consists of six blast furnaces, of which four or five active units supply the normal full operation requirements of 15—120-ton Open Hearth furnaces and 2—12-ton Bessemer converters. Two blooming mill units produce slabs, blooms and billets for trans-shipment to the finishing mills which are located at a distance from the Ohio Works.

Main steel works prime movers consist of reciprocating steam and gas engine blowers for blast furnaces and converters and steam engine drives for blooming mills and their supplementary roll trains. Steam engines use 150 lbs. steam at limited superheat. In addition to the normal steel works auxiliary steam requirements a 3700 ft. steam line carries 800 H.P. of 150 lbs. superheated steam to the Union Works for heating and auxiliary requirements.

All A.C. power for the district is generated at 25 cycles in the Ohio Works power plant by six gas engine generators of 17,200 K.W. total rated capacity and two 15,000 K.W. turbo generators, designed for 240-lb. gauge pressure and 540° F. total temperature. A.C. power is transmitted over high tension lines to the electrified finishing mills and distributed to the general Ohio Works system for auxiliary drive requirements.

Previous to installation of the new boilers, steam generating equipment consisted of 15—550 H.P. fire tube waste heat boilers with economizers and superheaters, installed on open hearth furnaces and operating at 150-lb. pressure; six 1260 H.P. bent tube, underfeed stoker fired boilers producing superheated steam at 250 lbs or 150 lbs. pressure, as required; and 48 scattered and inefficient blast furnace gas fired boilers averaging 350 H.P. each and producing 150 lbs. saturated steam for general mill use. The immediate demand for added steam generating capacity was the necessary replacement of these latter units.

Blast furnace gas in excess of stove requirements was utilized in gas engine blowers and generators and in the displaced boilers. Soaking pit fuel was producer gas. Open hearths were fired with tar or producer gas, the proportions depending on the availability of the by product tar. Without coke oven gas as an enriching fuel or an economical high BTU substitute, and with finishing mills located at a considerable distance from the source of blast furnace gas, utilization of this fuel for metallurgical purposes was practically limited to soaking pit use. This is contemplated as a part of the general program of which the boiler plant was the first step. Powdered coal was selected as the logical auxiliary boiler fuel.

The possibility of major future steam economies was anticipated in the installation of new boiler units, de-

C. H. WILLIAMS

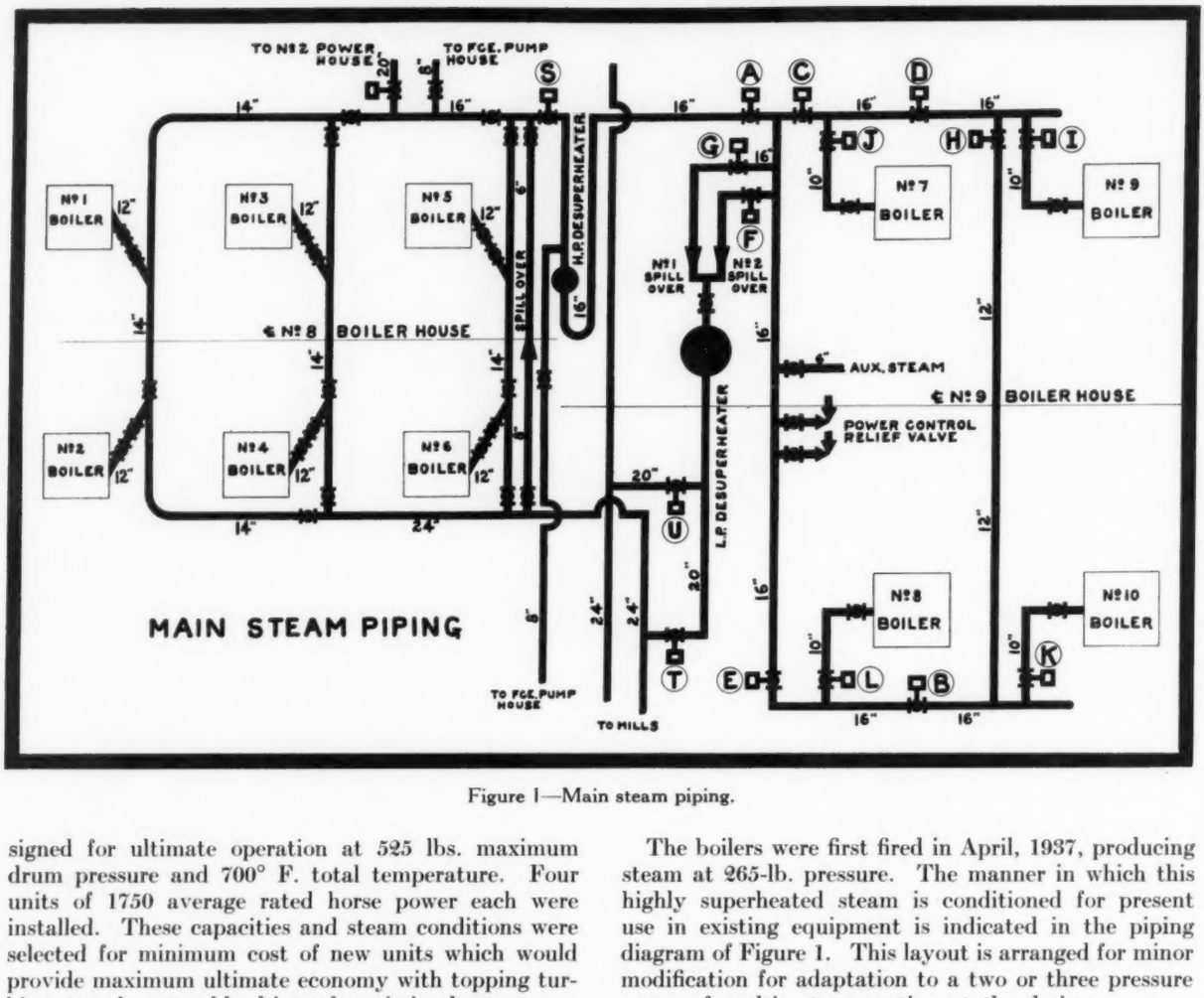


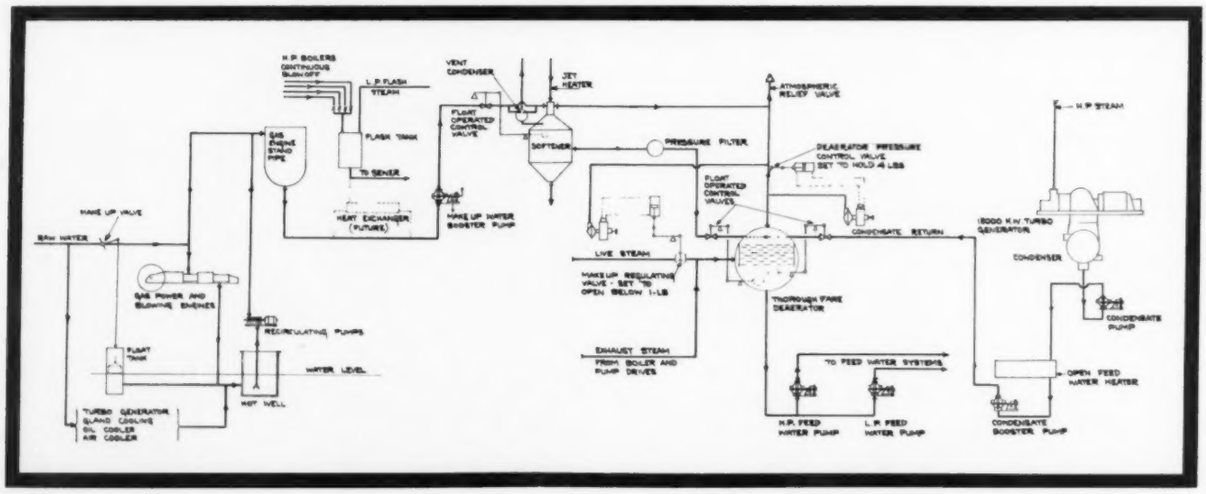
Figure 1—Main steam piping.

signed for ultimate operation at 525 lbs. maximum drum pressure and 700° F. total temperature. Four units of 1750 average rated horse power each were installed. These capacities and steam conditions were selected for minimum cost of new units which would provide maximum ultimate economy with topping turbines to exhaust or bleed into the existing low pressure system and balance the supply of waste heat steam to low pressure consumers. Maximum economy and flexibility in the adaptation of extraction or back pressure units was available at these conditions with the minimum cost of new high pressure units.

The boilers were first fired in April, 1937, producing steam at 265-lb. pressure. The manner in which this highly superheated steam is conditioned for present use in existing equipment is indicated in the piping diagram of Figure 1. This layout is arranged for minor modification for adaptation to a two or three pressure system for ultimate operation at the design pressure. The pressure reducing control stations are equipped with high pressure cutout control elements to protect the high pressure system in preference to the low in case of major steam shortage.

The boiler program includes a water softening plant

Figure 2—Feed water flow.



and essential auxiliary equipment. Figure 2 illustrates the feedwater cycle. Note that the clean water for boiler feed is first employed as a recirculating medium for gas engine cooling by which its temperature is raised to an average of 140-160° F. depending on initial temperature and operating conditions. Feedwater makeup flows by gravity from the standpipe of this system to the softening plant where it is pumped into the jet heaters of a double tank hot process softener. Surface condenser condensate and softener effluent flow to the 1,000,000 lbs. per hour deaerator by gravity and thence to the high and low pressure feedwater pumps.

The steam pressure in the thoroughfare type deaerator is held constant at about 4 lbs. by a control butterfly in the exhaust steam outlet to the softener heaters. If exhaust steam from auxiliaries is inadequate for the softener-deaerator system, a live steam valve introduces steam to the deaerator inlet in response to a softener supply pressure just above atmospheric. This valve closes off completely at a pressure below the atmospheric relief valve setting.

Figure 3 shows a cross section of the boiler house and indicates the general arrangement of boilers and main auxiliaries. Pairs of boilers on opposite sides of the house are of different manufacture and have minor variations in design details. The elevations of Figures 4 and 5 show major features of the "A" boilers on the left and the "B" boilers on the right. Figure 6 shows comparison of the plan details.

The lower combustion chamber walls of the "A" boilers, Figures 4 and 6, are the stud tube type with block covered hopper bottoms. The stud tube construction presents a partial refractory radiating surface to the flame. The lower walls are backed up with plastic refractory, an intermediate air space and insulated steel panels. Side and front walls above the upper water wall headers are sectionally supported refractory, backed up with block insulation and steel panels. Water wall risers from the side wall headers are carried to the upper front drum inside the upper combustion chamber; in the front wall these risers constitute a continuation of the lower front water wall surface and form a sloping roof section at the top front of the setting; back water wall tubes are rolled into the mud drum and internally connected through the same to form the twelfth convection pass terminating in the middle drum. Feeders from the mud drum to the lower water wall supply headers and recirculator tubes between upper and lower water wall headers are built into the lower combustion chamber panels, eliminating all external piping.

Combustion chambers of the "B" boilers, Figures 5 and 6, are of the fin tube type, presenting a total black surface to the flame. These walls are backed up

Figure 3—Section of No. 9 boiler house.

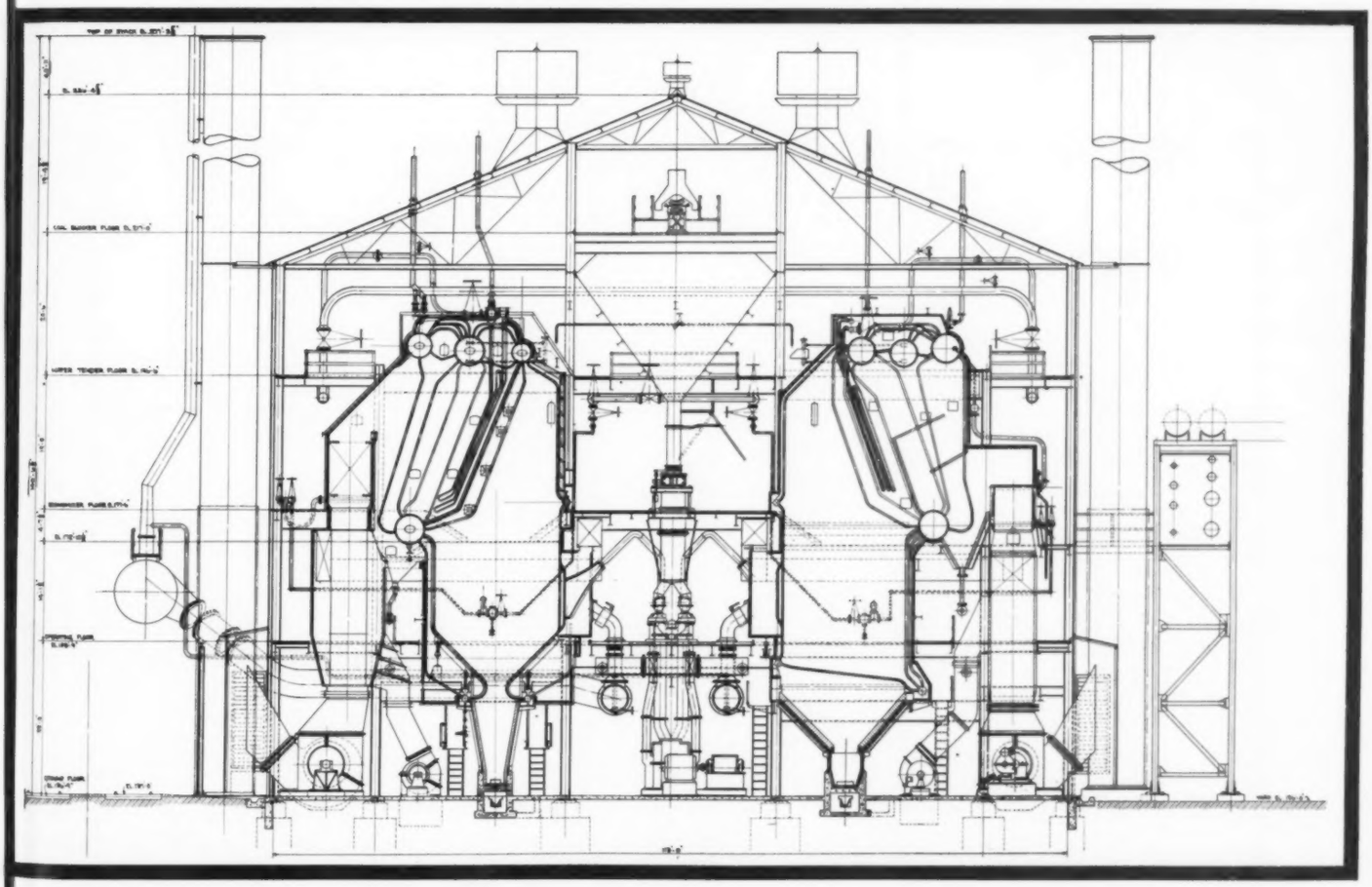
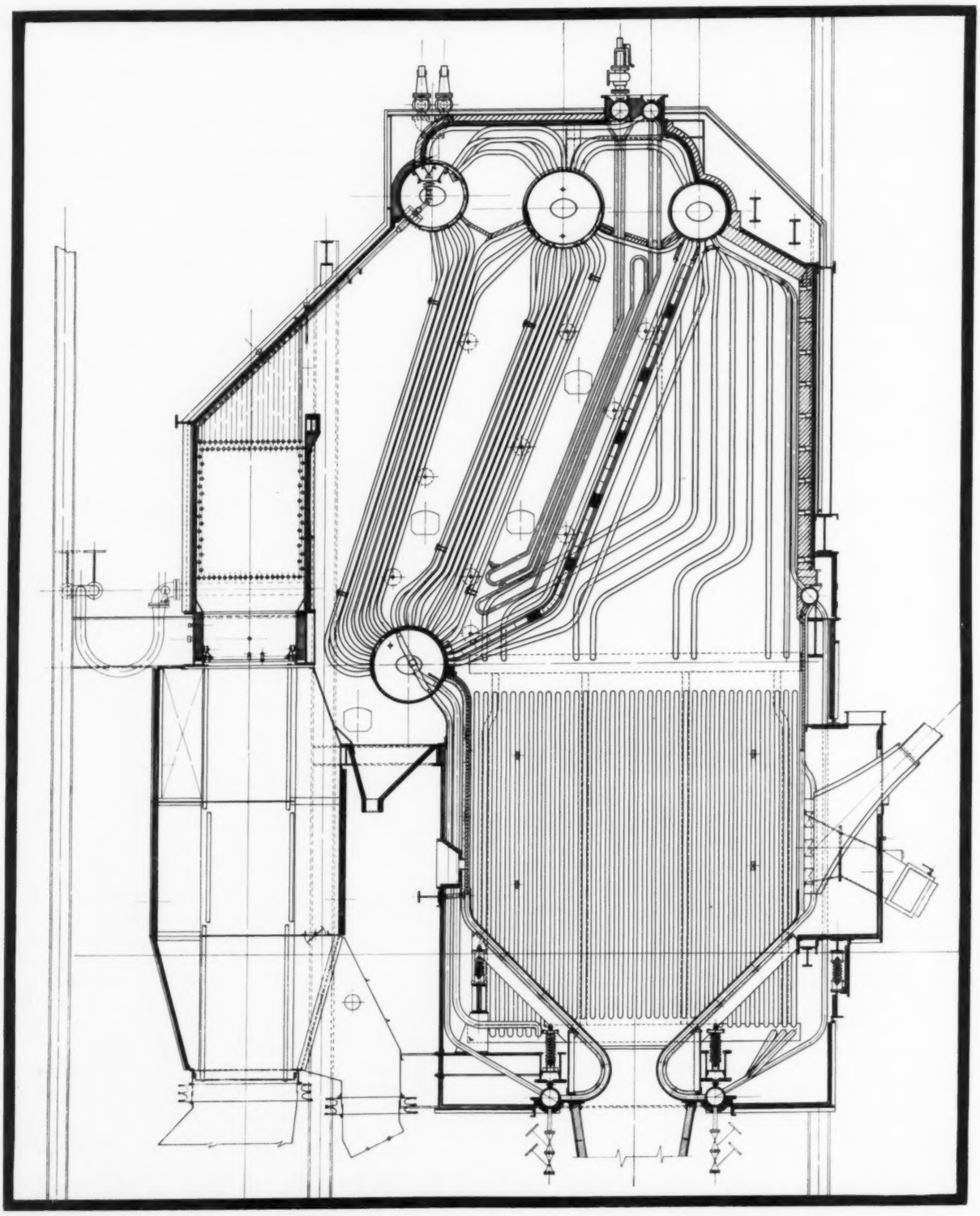


Figure 4—Section of boiler "A".



with special tube fitting refractory blocks, blanket insulation and steel panels. Bottoms are of refractory construction shielded by slag screen tubes. Upper walls are sectionally supported and insulated except in the front wall where the insulated fin tube block construction is similar to that in the combustion chamber and is carried over the upper front section to form the sloping roof enclosure. In these units, side and rear water wall headers are fed directly from the mud drum. Supply tubes are encased in the steel panels behind the rear wall tubes. Rear wall tubes extend upward through the mud drum and form one row of convection tubes in the second bank. The slag screen tubes are fed from the rear header and terminate in the lower front wall header. Front wall tubes rise upward through the intermediate header to the upper front drum. The side wall risers from the upper headers terminate in the upper center drum.

Refractory lined steel plate ash hoppers with concrete bottoms are adapted to the bottom construction of each type boiler and are supplied with quencher sprays and oscillating type cleanout nozzles. The ash is sluiced off of a sloping bottom into an ash transport trench equipped with nozzles which convey the ash to an outside sump for drainage and disposal.

The convection banks differ mainly in the drum sizes, method of baffling and manner of steam collection. In both types the front row of tubes is wide spaced in spread rows to form a slag screen.

In the "B" boilers, Figures 5 and 6, the four front tube rows are rolled into the upper front drum and the four rear tube rows are rolled into the upper rear drum; alternate tubes of the intermediate rows are rolled into front and middle or middle and rear drums. There are no direct water circulating tubes between upper drums and no steam circulating tubes between the upper front and center drums; both the upper front and center drums discharge their steam directly to the rear drum through double rows of steam circulators. Front and center drums are both 42″ in diameter, the front drum centerline being 3″ higher than the center. The 48″ rear drum centerline is 9″ above that of the center drum. Steam discharges into the rear drum through a washer screen over which the feedwater supply pipe discharges and out through a dry screen to the superheater collector tubes.

Feedwater enters both ends of the upper rear drum through external connections from the economizer, flows over the screen washer, downward through the rear bank and then upward into convection tubes or downward into water wall supply headers. Water columns and feedwater regulator generators tap the center drum. There are four full rows of boiler tubes ahead of the return bend superheater. Alternate rows consist of double loop and triple loop elements.

Tile and monolithic baffles circulate waste gases upward and to the rear across the slag screen tubes, superheater and front convection tube bank, reversing twice across the second and third convection banks in a general downward pass and out above the mud drum into the economizer connection. Ten soot blower elements extend halfway through the bank from either side at locations indicated on Figure 5.

In the "A" boilers, Figures 4 and 6, all front, rear and side water wall tubes and three full rows of tubes in the front bank are rolled into the 36″ front drum, the next 12 rows enter the center drum and the rear 5 rows the rear drum. The center line of the front drum is 3″ below that of the center drum. 2 Rows of steam circulators lead to the 48″ center drum; 4 rows of steam circulators lead from the center drum to the 42″ rear drum, the center line of which is 9″ above that of the center drum. A spray type scrubber is installed in the rear drum.

Feedwater is fed from risers fanned upward from individual economizer elements, rolled into the rear drum and through same to the scrubber manifold. These riser tubes form a full width upper rear casing for the setting. Feedwater flow is downward to the mud drum and then upward to convection banks or downward to water wall supply headers. There are three full rows of tubes ahead of the double loop return bend superheater.

The second full row of boiler tubes, immediately behind the slag screen tubes, support the special intertube refractory blocks which form a filter baffle, the the first stage of the single pass arrangement, which distributes the combustion products over the whole tube bank in a single path transverse to the tubes. In addition to this refractory baffle, three rows of tubes, one immediately behind the superheater, one at the rear of the second bank and one at the rear of the third bank are bent out of normal spacing to form a very close, tight pass with respect to the adjoining normally spaced rows to maintain this spread flow. Ten soot blower elements are installed in either side of the setting as indicated in Figure 4.

Water wall supply headers and mud drums of all boilers are equipped with 1½″ double tandem seatless blowoff valves. Continuous blowoff is taken from the upper center drum of each boiler through graduated control valves; continuous blowdown is led to a 150-lb. flash tank tied in to the low pressure steam supply with provision for ultimate installation of a second stage recovery blowdown heat exchanger. The mud drums of all boilers are tapped with lines supplying secondary feedwater chemicals.

Economizers and air preheaters are installed as heat recovery equipment on all boilers. In the "A" boilers, economizers are of the return bend type, 20 elements wide and 19 rows deep. Two horizontal rows of four soot blower elements are installed for cleaning the staggered tube banks. Waste gases flow downward in a single pass through tubular air preheater elements discharging to the induced draft fan inlet; traveling head soot blower elements traverse the opening above the upper tube sheet blowing down through the staggered gas tubes. Combustion air flows around the tubes in a baffled three pass upward flow to the top burner air duct connection.

In the "B" boilers, the economizer is of the extended surface return bend type, 19 elements wide by 8 rows deep with a single horizontal row of four soot blower elements located centrally in the tube bank. Gas flow is divided out of the economizer, flowing downward through the gas slots of a double compartment plate type air preheater and into the induced draft fan inlet

housings. Side access plates are provided for hand lancing these gas passages. Combustion air from the forced draft fans is split to the opposite heater compartments flowing in, up and out in an S-shaped pass in the slots between the gas passages and to the top hot air duct connections.

Turbine driven forced draft fans and geared turbine driven induced draft fans are located at ground level, the latter discharging to external steel plate stacks. All heat recovery equipment and ducts are insulated with block or built up panel type covering. Louvre dampers are installed in both fan outlets for shut off only; fan speed and output are controlled entirely by means of steam turbine control valves.

Combination coal and gas burners on all boilers are identical. They are the intertube type, firing between the spacing of the front water wall tubes as indicated in the plan and elevation of Figure 7. There are four gas burner compartments and three intermediate coal burner compartments, built into the common burner box and supplied with air from the common preheated air duct through gang operated louvre dampers located in the top of each compartment. Blast furnace gas is a combination of tower-washed, Feld-washed and precipitated gas of around .12 grains average dust content, supplied to these burner batteries through separate headers suspended under the operating floor, with vertical goose neck risers to the individual burner compartments. Gas flow is controlled by a main butterfly valve in each header as described subsequently. Gas flows to the combustion chamber through the vertical slots or fingers of the inner gas burner castings which project between adjacent tubes of the front wall. The narrow clearance between the fingers of these castings and the adjacent tubes serves as the combustion air passage from the compartment air plenum chambers. Gas and preheated air mix rapidly in long thin ribbons with intimate mixing and quick combustion.

In the coal burner compartments, the primary air and pulverized coal stream is discharged through a narrow vertical slot between adjacent tubes which are bent back and spread out of normal alignment to serve as a supporting and cooling device for the inner casting. Secondary air is supplied from the compartment air plenum chamber through staggered adjustable ports on either side of the fuel stream, which promotes intimate mixture.

There are two pulverizers installed on the ground floor below the firing aisle, each capable of developing full rating on one of the two opposite boilers; mills are spaced for ultimate installation of two more units when required. These mills are the high speed hammer and attrition type with double end feed, common center discharge and internal fans and classifiers. The pulverizer discharge is connected by means of a reversible adapter pipe to one or the other of two risers each of which divides through a three way splitting valve to the three burner connections of opposite boilers. Only one boiler at a time can be connected to either pulverizer. Coal is fed from duplex table type feeders on the operating floor level, discharging to opposite inlet ends of the double mill; rate of coal feed is adjusted by varying the feeder table speed as described subsequently. Coal is supplied to the feeders from overhead bunkers and automatic coal scales. Primary air is supplied to the mill from the preheated air duct of that boiler which is connected to the pulverizer, with provision for cold air tempering as required. Primary air dampers open and close as the feeders go in and out of service as described subsequently.

Location of fans, pulverizers and ash sluicing trenches are indicated in the ground floor plan of Figure 8.

Feedwater is supplied to the boilers through a sectionalized looped header. Individual boiler feed is taken through a single metering line which splits to dual feedwater regulator valves on opposite sides of the boilers located at the firing floor level. These lines reconnect at the economizer inlet. An intermediate deck at the economizer level gives access to economizers, mud drums, coal scales and desuperheaters. The top deck gives access to main steam valves, upper drums, water columns and feedwater regulator generators.

Instrument and control boards are mounted on the firing floor in the side aisle as indicated on the plan of Figure 9. Individual boiler panels are located back to back facing their respective units with the regulators mounted behind these boards in the enclosure formed. The double-side, central master panel forms a similar enclosure for control mounting. One end section of this panel is utilized as a control station for main motor operated valves.

Individual boiler panel instrument equipment consists of indicating, recording and integrating meters for steam, feedwater and blast furnace gas, CO_2 recorder, steam and feedwater temperature recorder, water level recorder, four point stack gas and preheated air temperature recorder and indicating pressure and flow gauges for gas, air, stack gases, coal feed and air flow.

Master panel instrument equipment consists of indicating and recording totalizing gas and steam flow meters, recording and integrating auxiliary steam flow meter and gas bleeder meter, master steam temperature and pressure recorder, gas pressure and temperature recorder and two recording and integrating test flowmeters which are arranged for quick connection for measurement of auxiliary steam flows, blowdown, and for miscellaneous test purposes.

The functions performed by the boiler control equipment may be summarized briefly as follows:

1. Regulate fuel input in accordance with load demand, so that blast furnace gas is utilized up to the maximum of availability and coal is fired only to supply any deficiency.
2. Protect blast furnace gas supply to primary gas users and relieve the system of excess pressure when supply is in excess of the total demand.
3. Maintain correct supply of air for combustion of any combination of fuels being fired.
4. Control removal of waste products from boilers so as to hold a constant combustion chamber pressure.
5. Prevent firing rates beyond the capacity of the fan auxiliaries and eliminate explosion hazard in case of their failure.
6. Provide flexibility in adjustment of load and combustion conditions and means for manual or emergency manipulations.

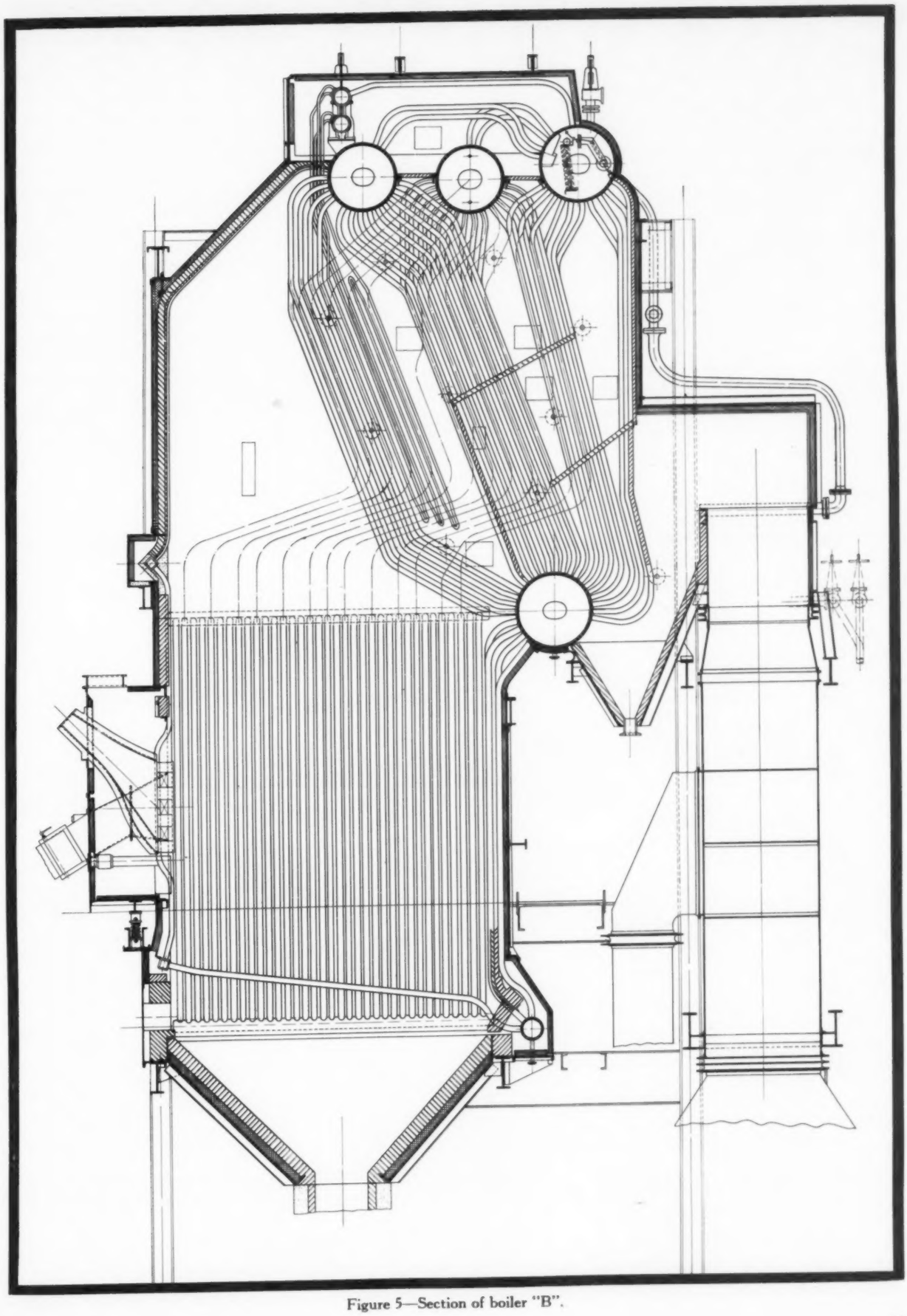


Figure 5—Section of boiler "B".

These functions are accomplished by the following regulator units:

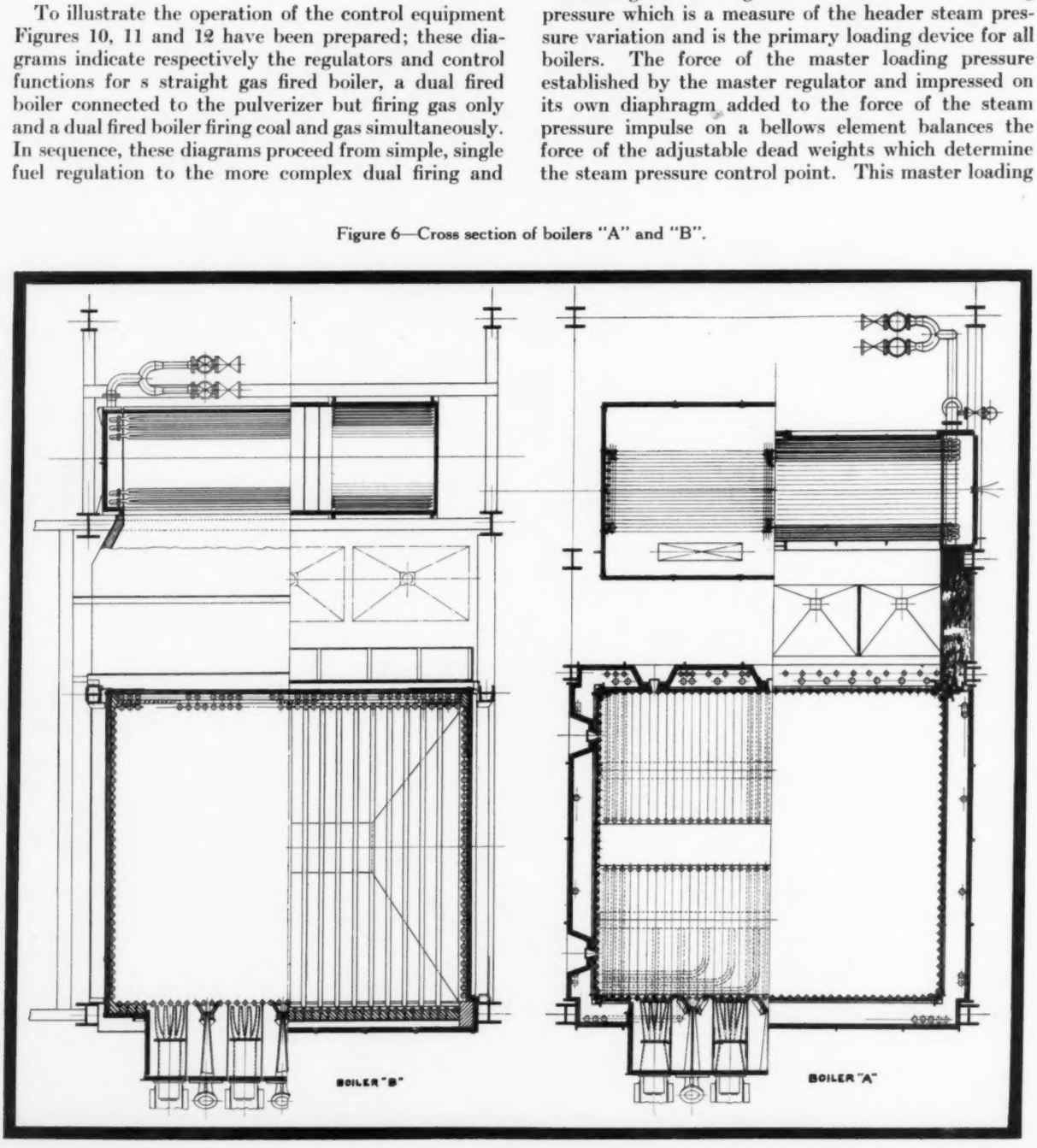
A. 1—Master Regulator.
B. 1—Maximum Gas Pressure Regulator.
C. 4—Minimum Gas Pressure Regulators, 1 per Boiler.
D. 3—Primary Regulators per boiler, controlling:
    1. Fuel Feed.
    2. Air Supply.
    3. Furnace Pressure.
E. Transformer regulators for combination firing. 4 common to each pulverizer or pair of opposite boilers.

To illustrate the operation of the control equipment Figures 10, 11 and 12 have been prepared; these diagrams indicate respectively the regulators and control functions for s straight gas fired boiler, a dual fired boiler connected to the pulverizer but firing gas only and a dual fired boiler firing coal and gas simultaneously. In sequence, these diagrams proceed from simple, single fuel regulation to the more complex dual firing and also follow the control performance from the condition of excess gas over and above all requirements to a deficiency of gas requiring coal firing. These sketches show diagrammatically the boilers, main auxiliaries and control regulators as arranged for each firing condition. All the "throwover" valve details have been eliminated to avoid complication.

Figure 10 illustrates the controllers for a straight blast furnace gas fired boiler and the conditions of regulation where there is an excess of gas over all requirements. There are always two boilers firing straight gas with controllers as indicated.

The single master regulator establishes an air loading pressure which is a measure of the header steam pressure variation and is the primary loading device for all boilers. The force of the master loading pressure established by the master regulator and impressed on its own diaphragm added to the force of the steam pressure impulse on a bellows element balances the force of the adjustable dead weights which determine the steam pressure control point. This master loading

Figure 6—Cross section of boilers "A" and "B".



pressure is therefore proportional to and a measure of the steam pressure drop from the maximum setting; it can be demonstrated that this drop is a second power function of the total steam flow and consequently that the loading pressure is approximately a differential measurement of the fuel required to balance the load demand.

The master loading pressure is imposed on the loading diaphragm of the fuel regulator. The fuel regulator positions the gas butterfly valve to maintain a gas flow differential in proportion to the master loading pressure; thus a metered gas flow is balanced against the measured demand for fuel.

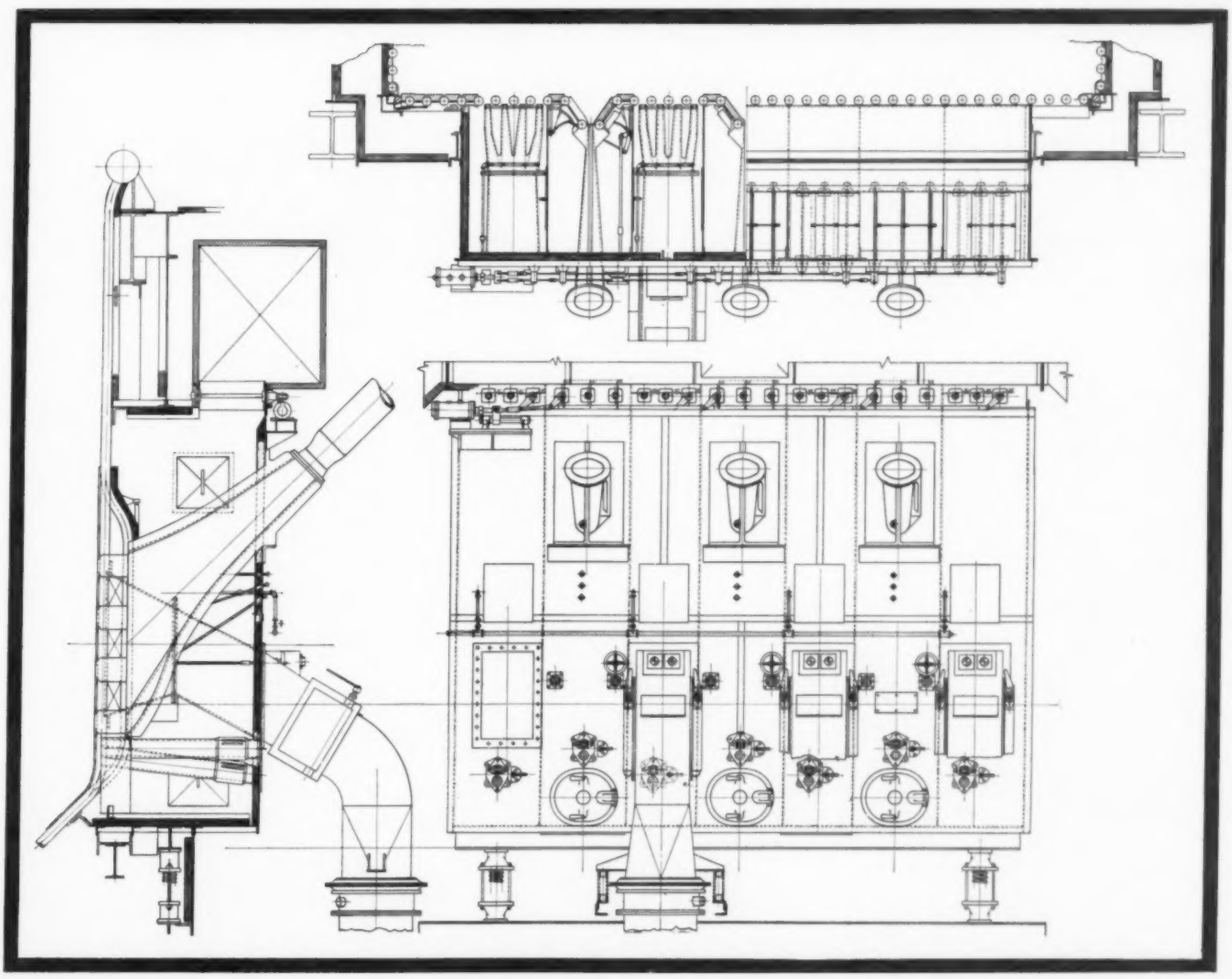
Note that the gas butterfly valve is also controllable by means of the cylinder of the minimum gas pressure regulator through a "whiffle tree" linkage. Either cylinder, operating through its full stroke, will move the butterfly control valve through its full regulating arc; it will develop subsequently that one or the other of these cylinders is always in the full stroke position, allowing the alternate cylinder to assume complete regulation of the gas valve. In this particular case the minimum pressure regulator is in the full open position, and the fuel regulator cylinder has partially closed the valve to throttle the gas flow to that value required to satisfy the loading pressure or fuel demand. Control of the gas valve from the minimum gas pressure regulator is described subsequently in connection with combination firing.

The single maximum gas pressure regulator is shown operating a gas bleeder valve to maintain a constant maximum pressure and to bleed gas which would otherwise build up excess pressure when the total supply is more than the total required by all consumers.

The combustion regulator loading impulse is the gas flow differential; this regulator controls the position of the forced draft fan turbine valve and consequently regulates the speed and output to create a metered air flow differential, measured at the fan outlet, proportional to the gas flow. Thus a metered supply of combustion air is balanced against the metered gas flow. This regulator is supplied with a hydraulic stabilizer which is adjustable to match the speed of regulation with the inertia of the fan, turbine and air system, preventing hunting.

The furnace pressure regulator, controlling the induced draft fan turbine steam valve, balances the furnace pressure impulse against an adjustable spring loading to hold a constant combustion chamber pressure. This regulator is also equipped with a hydraulic stabilizer.

Figure 7—Combination Blast Furnace Gas and Powdered Coal Burner.

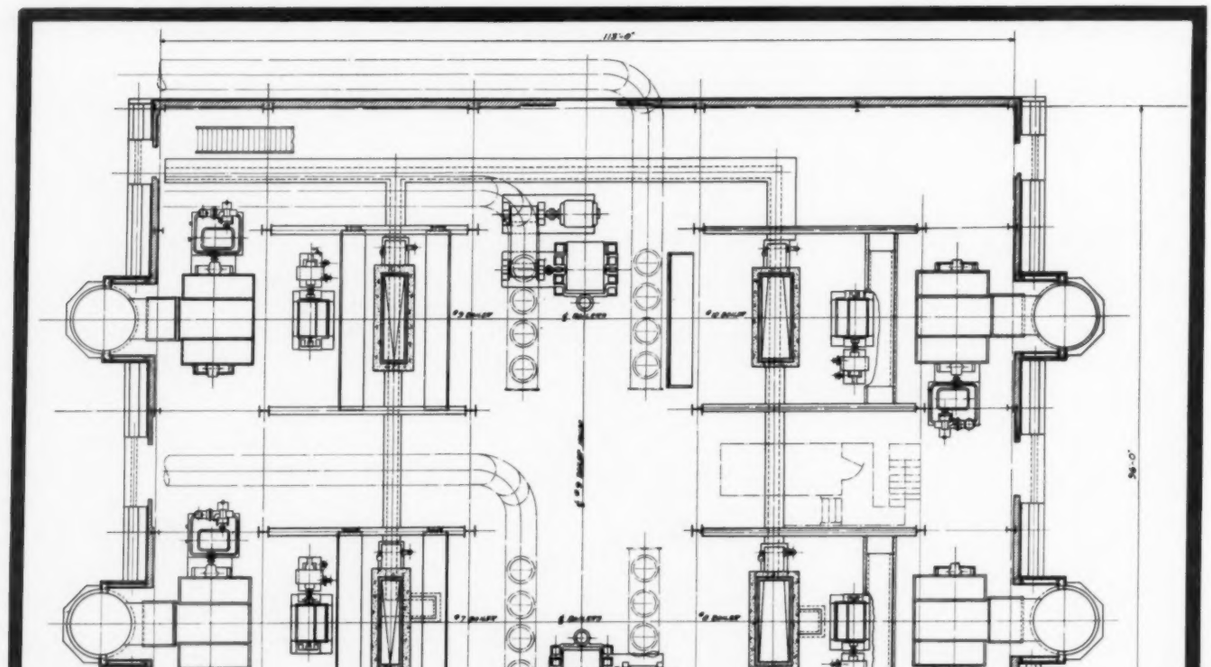


The control illustrated and described above performs the simple functions of regulating fuel imput, air supply and furnace pressure for a boiler firing straight blast furnace gas. With an excess of gas as predicated above, all boilers would be firing at relative rates and would be controlled essentially as illustrated, throttling the gas flow to balance the master loading pressure. In order to develop the more complicated features of the dual firing control, we should now proceed to a consideration of the hookup for combination firing and follow the regulation from the condition of gas excess, as above, to a gas deficiency calling for coal firing. The objective is to fire boilers at comparable or proportional rates, utilizing all gas available after satisfying other consumers and firing coal only in case the gas supply is inadequate.

In combination firing, we no longer have the simple problems of balancing a single fuel against load demand and supplying combustion air for a single fuel. We must now single out that portion of the total fuel demand which can be supplied by the gas available, determine the deficiency in this supply and fire coal in proportion to the deficiency. Since it requires a different amount of air for equivalent heat input for the two fuels and since it is not physically possible with the burner arrangement to divide or accurately measure the air flow for each fuel individually, we must summarize the air required for any combination of fuel conditions, supply combustion air in accordance with this summarized requirement and then split the total approximately in accordance with the requirement of each. To accomplish these functions a group of transformer and splitting regulators are employed for each pulverizer; these regulators are so valved that they are switched to operate in conjunction with the primary regulators of either of the two boilers which may be fired with each pulverizer.

Figure 11 illustrates the control setup for the same

Figure 8—Grade floor plan.



boiler as above when it is connected to the pulverizer and is consequently available for combination firing. The operating condition illustrated is for the transition period when there is a very slight gas deficiency which is not yet of magnitude to require coal firing. But two of the four additional regulators are shown since only these function as long as gas only is fired.

Note first the changes from the previous illustration in the gas controlling regulators. The gas is now inadequate, either due to decrease in total gas produced, increase in the consumption of other users or greater fuel demand for steam. The excess gas and excess gas pressure have disappeared and the bleeder valve has been closed by the maximum gas pressure regulator. As the supply pressure falls or fuel demand increases, the fuel regulators on all boilers open up to satisfy the loading pressure demand for fuel. As the gas pressure continues to drop, a point is reached where the supply pressure to straight gas fired boilers and other consumers is hazarded. At a predetermined pressure setting, the minimum gas pressure regulator on the boiler shown, which is valved to fire coal on first requirement, begins to throttle the gas flow to this boiler to hold the minimum gas pressure for which it is set. As the minimum gas pressure cylinder starts to close the gas valve, depriving the boiler of the flow required to satisfy the master loading pressure, the fuel regulating cylinder will open simultaneously attempting to restore the balance. Eventually, therefore, the fuel regulating valve opens wide and the gas flow control on this boiler is transferred to the minimum pressure regulator in response to gas pressure variation. Note that when either of these butterfly valve cylinders is regulating, the opposite cylinder is in its maximum stroke position. The means by which gas is cut off selectively will be described subsequently.

We now come to the function of the submaster transformer and fuel splitting regulator which are always in operation on the two boilers connected to pulverizers. While the static master loading pressure is a measure of total fuel required it cannot be split accurately into component parts as such, since a second power function cannot be accurately divided into two impulses which will add to equal the original impulse. The Submaster Transformer, therefore, is used to create an equivalent flow impulse which can be so split. A supply of low pressure air is controlled by the submaster regulator so that its flow differential is equivalent to the static value of the master loading pressure. This flow becomes, therefore, a measure of the total fuel required exactly as the master loading pressure is a static measurement of that requirement.

The total flow from the submaster is directed into two branches of a split connection in which two valves are operated in opposite directions from a single cylinder linkage, one valve opening as the other closes. These valves are positioned by the cylinder of the fuel splitting regulator in such a way that the differential of flow through the upper branch is balanced against the actual flow of gas to the boiler.

Now, since the total flow from the submaster is a measure of total fuel demand and the flow through the upper branch is a measure of the gas available or actually being fired, any flow through the lower branch of the split must represent a measure of gas deficiency or coal required. As long as there is adequate gas and the gas flow is being controlled by fuel regulator cylinder, which would have been the case on a dual fired boiler in the previous example, the top fuel splitting valve will be open wide, the bottom valve will be closed, the differential in the top branch will equal the submaster differential and there will be no flow through the bottom branch. Whenever the minimum gas pressure regulator takes control of the gas flow, however, the gas differential will be less than the submaster differential, since the gas flow is less than the loading pressure demands. The fuel splitting cylinder will start closing the top valve and opening the bottom valve establishing a flow through the bottom branch which is the difference between total fuel demanded and gas fuel available and which can be calibrated as a measure of the coal required to balance the load demand.

Note that the loading impulse to the combustion regulator is now transferred to an orifice in the submaster system. As long as gas only is fired, this differential represents measurement of gas and consequently a measurement of air required to burn gas. The necessity for this change will be apparent in the next step.

The position of the fuel splitting valve cylinder is utilized to start the coal firing sequence since its first movement is an indication of the necessity for coal. In Figure 11, this valve is shown starting to move from its end position due to the throttling of gas by the minimum pressure regulator as described above. When an adjustable contact on this cylinder is made due to a given valve movement, the starting contactor of the main pulverizer is energized and the mill is accelerated through timing relays. When the running contactor of the pulverizer drive is closed, a second contact is made which performs the following functions:

1. Starts the coal feeder motor.
2. Opens the primary air dampers to the pulverizer.
3. Operates automatic valves which switch the impulse and oil connections of the fuel regulator from gas to coal control.

Figure 12 illustrates the full dual firing control hookup after the above operation is performed and the two fuels are being fired simultaneously.

It will be noted that the loading impulse to the fuel regulator is now the differential measurement of coal required from the lower branch of the submaster system. The controlled impulse is the differential of flow from a positive displacement blower whose speed is proportional to the speed of the coal feeder. By means of an adjustable knife blade setting on the feeder table the coal feed and blower air discharge are calibrated to give a metered measurement of coal to the pulverizer. The regulator cylinder adjusts the ratio lever of a variable speed drive to balance the measured coal feed differential against the measured demand for coal. Thus a measured coal feed is balanced against a measured deficiency of gas or a measured coal demand. Note that operation of the automatic valves for coal firing has locked the gas fuel regulating cylinder in the open position and the gas flow to this boiler is controlled

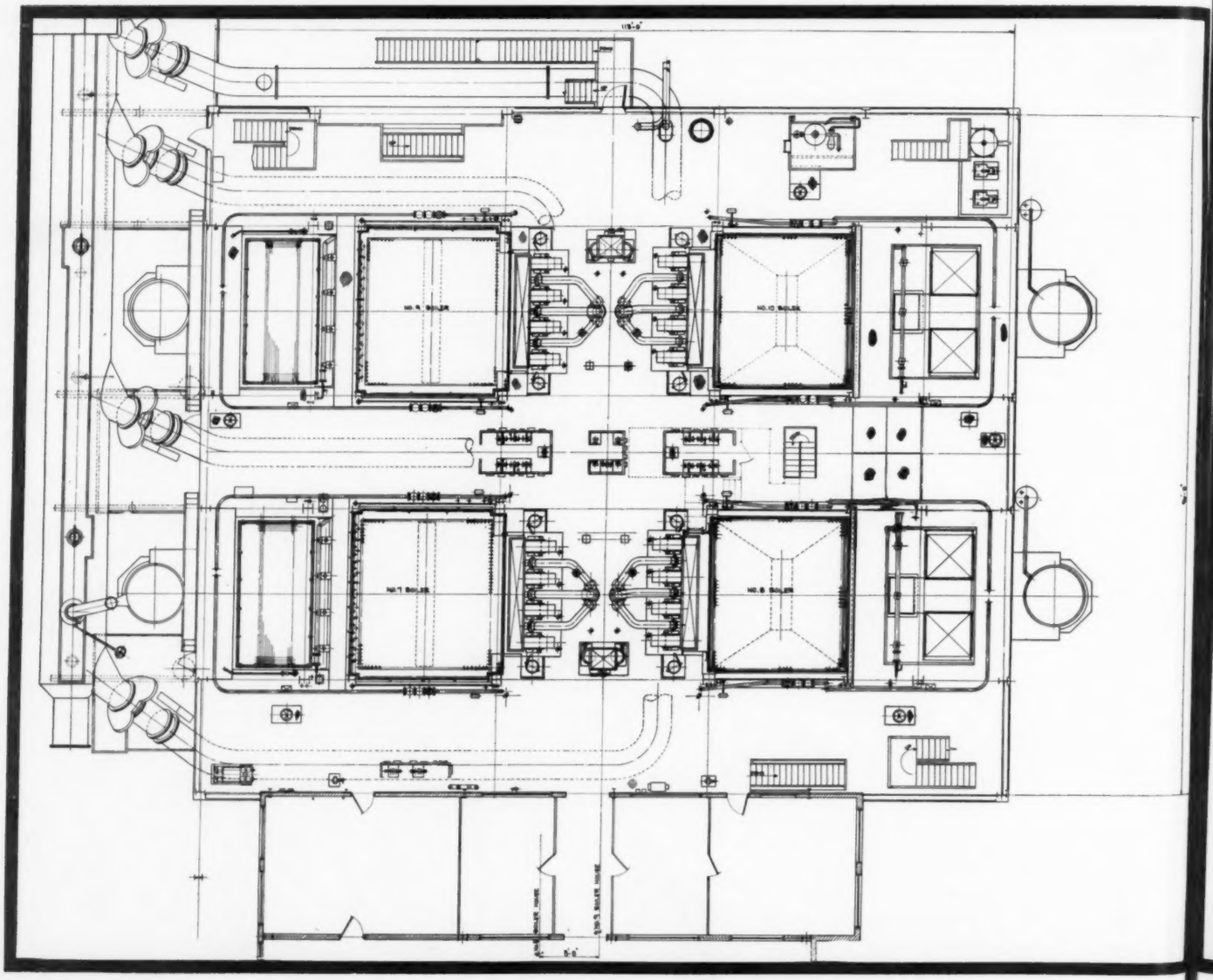
in accordance with the supply as indicated by the gas main pressure.

Since the quantity of air required for combustion of an equivalent number of heat units of coal and gas is not the same, a measure of total fuel demand does not represent a true measure of the correct air supply with varying proportions of the two fuels. As noted above, the flow through the orifices on the upper branch of the submaster system is a correct measurement of air required for straight gas firing. When coal is fired, an air-for-coal transformer regulator creates a flow of low pressure air which is a correct measurement of air for coal when passes through this same orifice; this flow is added to the flow in the upper branch; consequently the differential of the combined flow is a correct measurement of total combustion air required and is correctly employed as the loading impulse for the combustion air regulator.

Having established a correctly metered flow of combustion air for the combination of fuels it is necessary to split the flow from the common burner windbox to the two burner batteries in proportion to their individual requirements. This is accomplished by the air splitting regulator which operates the coal and gas windbox louvres in opposite directions, opening one while the other closes. The loading impulse to this regulator is the gas flow to the boiler. The controlled impulse is the air pressure in the gas burner box which is an approximate measure of air for combustion of gas. The balance of the correctly metered total air is automatically forced into the coal burners and pulverizer. Note that this arrangement automatically compensates for primary air to the pulverizers as a part of the total air required for coal firing. In both the preceding examples for straight gas firing these dampers were shown open to gas burners and closed to coal burners.

We have now followed the sequence of operations on both straight gas and combination fired boilers from

Figure 9—Operating floor plan.

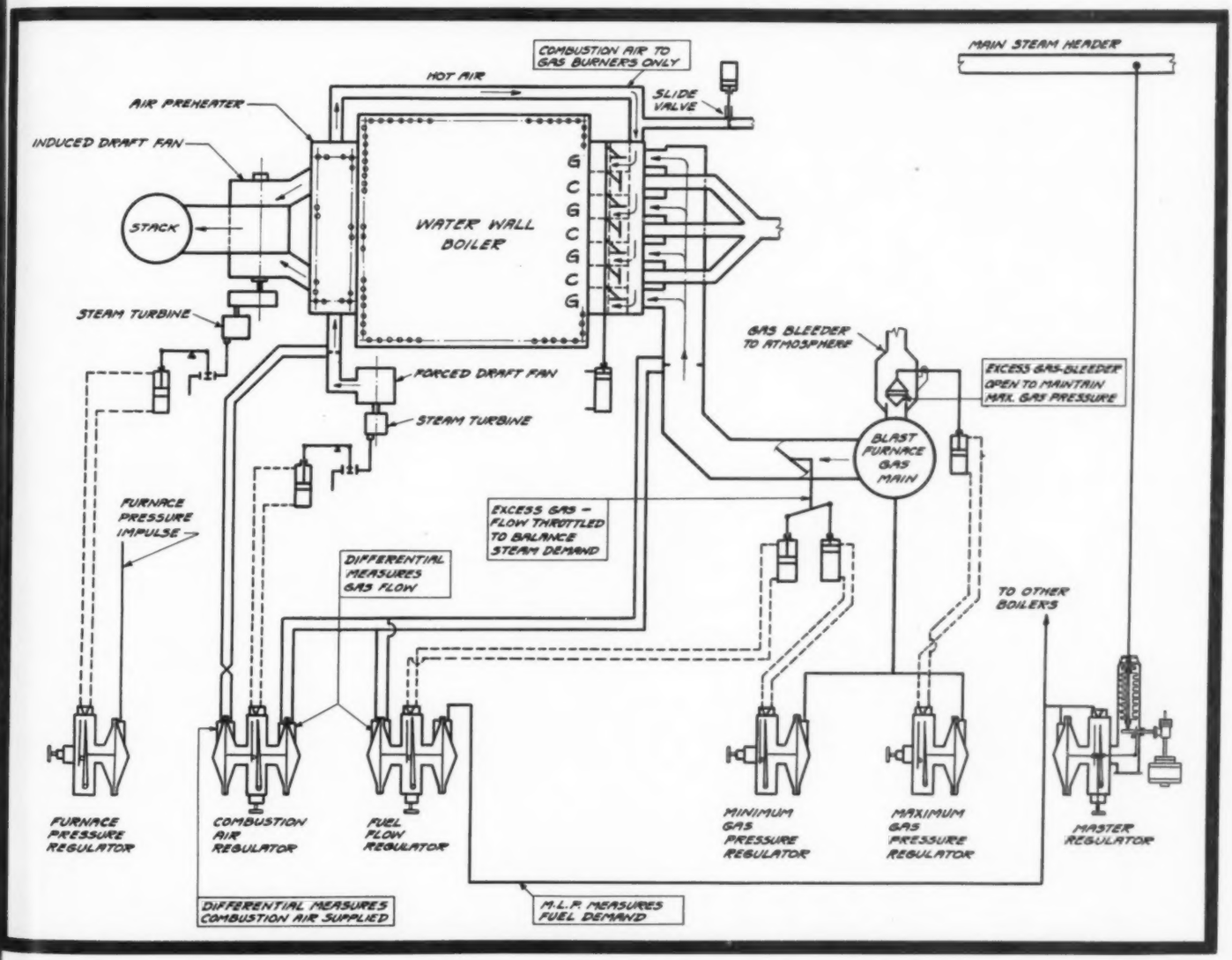


the condition of excess gas through to a condition of deficiency of gas requiring coal firing. As long as the shortage of gas exists, coal will be fired on the dual fired boiler in accordance with the actual gas deficiency. The gas flow to the boiler will be regulated by its minimum gas pressure regulator. If the gas valve of this boiler is closed to its minimum position and the gas pressure still continues to drop, indicating further gas deficiency, the minimum pressure regulator on the second dual fired unit will start closing at a slightly lower gas pressure, which will start and control coal firing on this second unit in exactly the same manner as described above. As the steam demand falls off or gas supply recovers, the reverse trend will proceed, dropping coal firing in the reverse order.

The following selective and manual manipulations are provided for:

A. Adjustment of the base steam pressure setting.
B. Adjustment of the controlled steam pressure variation or sensitivity of fuel response.
C. Adjustment of the relative load ratios or steaming rates of individual boilers.
D. Manual loading of individual boilers.
E. Adjustment of fuel air ratios for individual fuels or combination of fuels.
F. Adjustment of furnace pressure.
G. Manual positioning of all fuel and fan valve cylinders.
H. Selecting the pulverizer firing sequence.
I. Switching combination firing control between opposite boilers on each pulverizer.
J. Changing the pulverizer starting sequence from full automatic to semi-automatic. In the latter case the main pulverizer operates continuously and the coal firing impulse actuates the feeder drive directly, eliminating the accelerating delay.

Figure 10—Control for gas fired boiler. Pulverizer not connected. Firing gas only.



The discussion thus far has avoided any reference to the complicated valving of impulse and oil lines required to switch the transformer regulators between pairs of opposite boilers, to determine pulverizer sequence and to switch from gas to combination firing on the dual fired units.

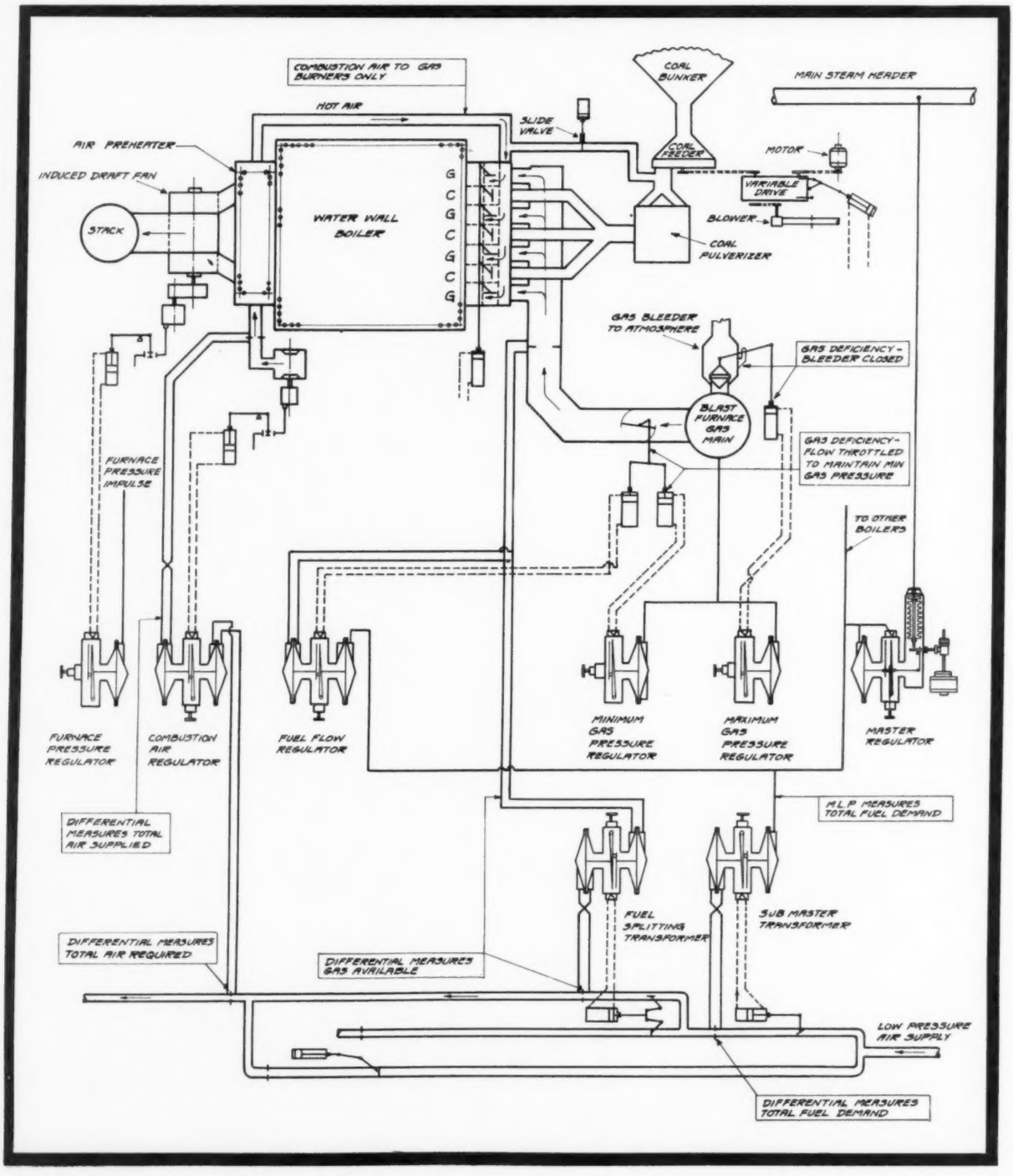
Briefly these operations are accomplished as follows:

A. The switch of dual firing control between pairs of opposite boilers is accomplished by manual operation of an oil valve which reverses the necessary impulse and oil lines through oppropriate hydraulic and mechanical linkages.

B. The switch from straight gas to combination firing on dual fired units is accomplished automatically by an electric contact on the fuel splitting regulator cylinder. This contact, either directly or following a time delay sequence, actuates a solenoid oil valve which reverses the necessary impulse and oil valves through appropriate hydraulic and mechanical linkages.

C. The pulverizer firing sequence is determined by manual operation of a selector valve which selectively loads the diaphragms of the minimum gas pressure regulators. The left hand diagram of Figure 13 indicates the method of this loading. The outer diaphragm

Figure 11—Control for combination fired boiler. Pulverizer connected. Firing gas only.

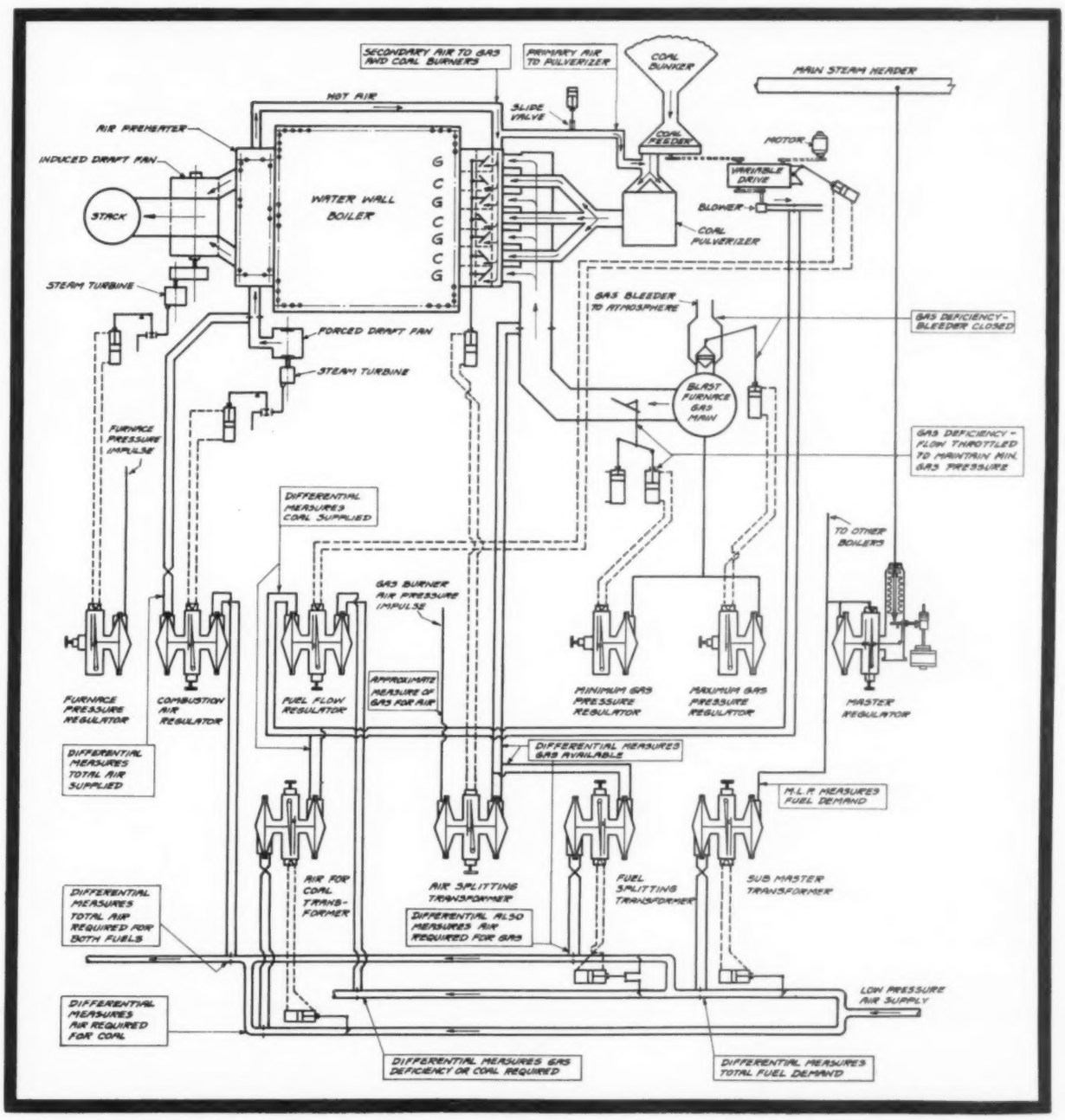


connection of the four minimum gas pressure regulators are all connected to the main gas line pressure. The reducing regulators A, B. C, and D are adjusted to hold staggered air pressure setting through three orifice bleed lines; they are shown set at 8", 7", 6" and 5" water column respectively. These pressures are valved to the various minimum pressure regulators and serve as loading pressures for these units. In the arrangement shown, with the pulverizer selector valve set for No. 1 Mill, the 8" loading pressure will be impressed on the regulator of the boiler connected to No. 1 Pulverizer and will consequently throttle gas and fire coal on this boiler first as gas pressure drops; the 7" loading pressure will be impressed on the regulator of one boiler connected to No. 2 Pulverizer and will consequently throttle gas and fire coal next in the sequence. The position of the boiler selector valves 7-8 and 9-10 is a part of the boiler selector switching and will depend on the pulverizer connection. It will be noted that switching of the pulverizer and boiler selector valves permits any sequence of operations desired.

The devices for limiting boiler rating to the capacity of fan auxiliaries and protecting against explosion due to their failure are also illustrated in the right hand diagram of Figure 13. This function is accomplished by holding the boiler load within the capacity of the fans or in case of fan failure completely unloading the boiler. The wide open position of the fan turbine steam valves is used as the indication of failure or capacity limitation since in either instance the regulator positioning these valves will open them wide to attempt to overcome the indicated fan deficiency regardless of its cause.

The fan failure relay for the forced draft fan consists

Figure 12—Control for combination fired boiler. Pulverizer connected. Firing gas and coal.



of a regulator body housing and a leakport valve bleeding a low pressure source of air to atmosphere through an orifice plate. A loading pressure line to the inside of the fuel regulator diaphragm is connected between the open end discharge and the orifice which is calibrated to give zero pressure when the swinging arm is out of contact with discharge port. This arm is normally held out of contact by compression of the calibrating spring. When the fan valve cylinder approaches the wide open position a roller contact rides up on a cam on the crank type cylinder arm; this roller contact push-pin pushes through the diaphragm to the swinging arm and partially closes the leak port opening. This action creates an air pressure which is opposed to the master loading pressure on the fuel regulator and consequently reduces the fuel firing rate to zero load or any intermediate rate within the fan capacity.

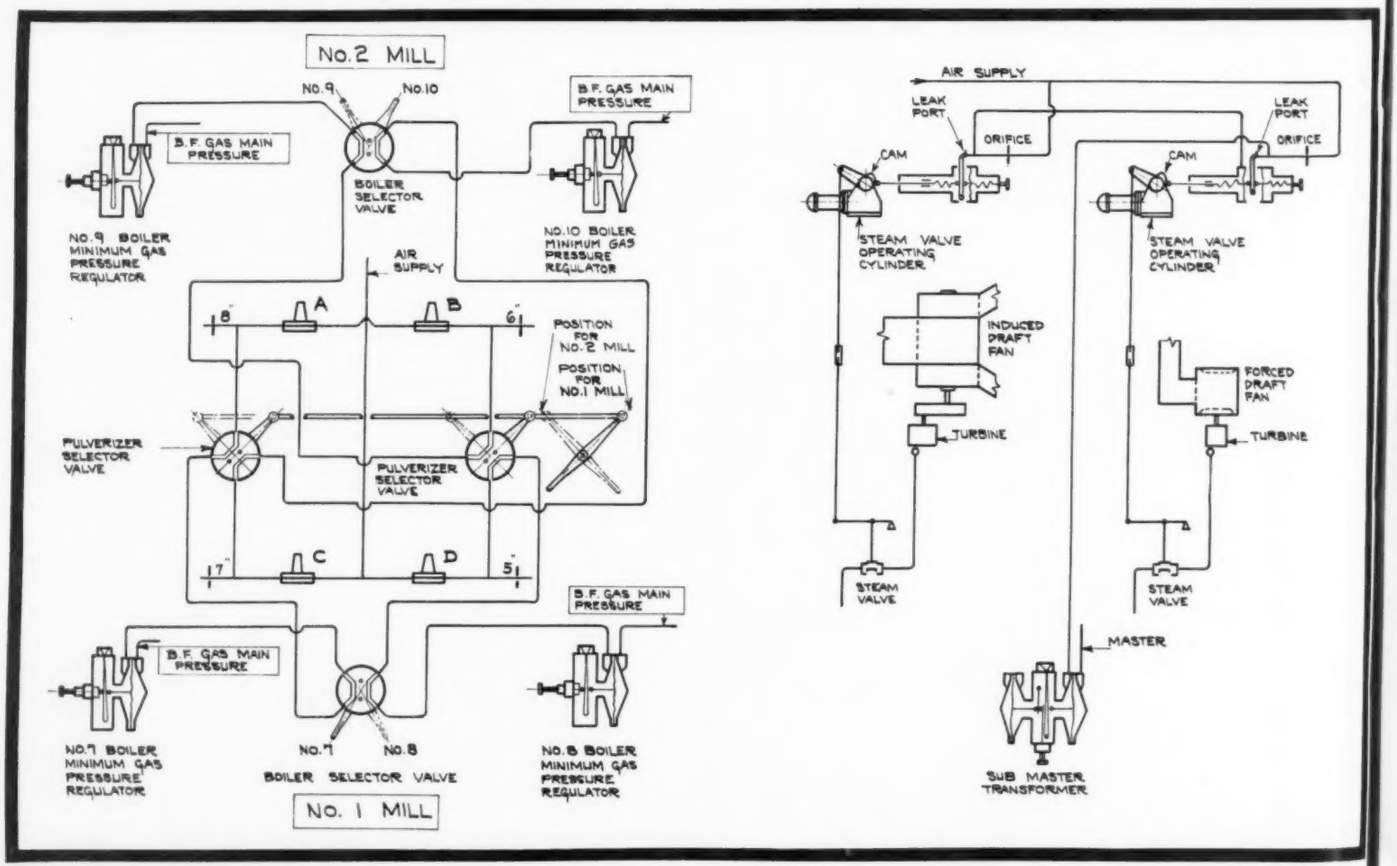
The induced draft fan failure relay operates in the same general manner except that the push-pin actuates the swinging arm directly and the loading pressure established is imposed on the diaphragm of the forced draft relay, which reacts exactly as if its own push-pin were causing the load reduction on the fuel regulator.

In the case of dual fired boilers the loading pressure from these relays is imposed on the inside of the submaster regulator loading diaphragm, again opposing the master loading pressure and reducing the total fuel demanded.

These boilers have operated up to the present time at 260 lbs. pressure instead of the design pressure of 475 lbs. This condition has introduced certain limitations in capacity due to abnormally high pressure drops in superheaters, main steam lines and auxiliary steam lines to fans. High pressure drop in the auxiliary steam lines, restricting the output of fan turbines due to low throttle pressure, has imposed definite limitations in gas fired output due to restriction in induced draft fan turbine capacity. Despite these handicaps, the four boilers have displaced the original gas fired and stoker fired units completely and have operated consistently at ratings of 150,000 lbs. per hour on gas only and 225,000 on gas and coal, peaking to 210,000 and 275,000 respectively on gas and combination firing.

Of the total plant week day steam load, approximately 25% is generated in waste heat boilers at essentially straight line output. The remaining 75%, carried by the new steam plant, concentrates the vicious swinging loads typical of steel plant operations. Breaks in the schedule of the two blooming mill groups increase or decrease the normal output of these boilers by roughly 10% and 25% instantaneously. This fluctuation is a minor consideration, however, compared with the recurring swings in steam to turbines supplying the continuous strip mill electric load superimposed on the normal bar mill electrical fluctuations. The magnitude of this swing is approximately 25% of the average

Figure 13—Left-Arrangement of boiler and pulverized selector valves. Right-Arrangement of fan load limit and fan failure relays.



boiler house output and it climbs from valley to peak and back to valley in a repeating cycle ranging from 40 seconds to one and a half minutes in amplitude.

This swing is so sudden and vicious that it must be met, at least in the initial upswing, and until fuel firing rate can be increased, by flash capacity in the boilers. Since the output of the two gas fired boilers, in initial operation, was essentially inflexible due to fan limitations, this total peak was necessarily met by coal firing on two dual fired boilers. The abnormally severe pressure drop in superheaters and steam lines, due to operation at half design pressure, induced excessive pressure variations in the main steam headers. When this turbine load comes on, the steam header pressure drops instantly as much as 15 lbs. which increases the master loading pressure and fuel demanded instantly. As the fuel firing rate is stepped up, header pressure is gradually restored, with the drum pressure skyrocketing to meet the increased superheater drop at higher flow. About the time equilibrium is restored for the new steaming rate the load disappears and the cycle is repeated.

As the steam pressure tumbles on the load upswing and the steam velocity in auxiliary lines to fans increases to handle the increased volume of air and gas, the drop in pressure at the turbine throttle becomes the limiting factor in output. Because of the abnormal pressure variations, relative steaming characteristics of individual boilers are drastically affected by their proximity in header connection to the point of major steam consumption, by the availability of coal and consequent fuel input flexibility and by minor variations in design details.

Coupled with these complications and limitations the fluctuations in gas availability due to changes in producing rate and consumption elsewhere are concentrated at the boiler house as the flywheel on the gas system. This total combination of circumstances imposes rather severe duty on boilers, boiler control and auxiliaries which is typical of most steel plant steam generating equipment.

The tabulation of Figure 14 indicates the essential operating date for a complete month and peak day during recent operation.

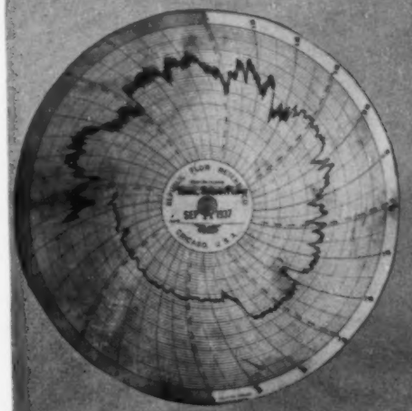
Figure 15 shows a series of 24 hour operating charts for a period from Friday midnight to Saturday midnight September 11th. These charts were selected to illustrate the functioning of the control in balancing fuel consumption over a wide range of steam requirements and to point out some of the varying load characteristics and operating limitations. These charts show for the 24 hour period:

Total steam output of the house
Total gas and coal consumed by boilers in the new house
Total gas bled from the system
Gas main pressure
Steam header pressure
Steam output and gas consumption of a straight gas fired boiler
Steam output and gas and coal consumption of a combination fired boiler.

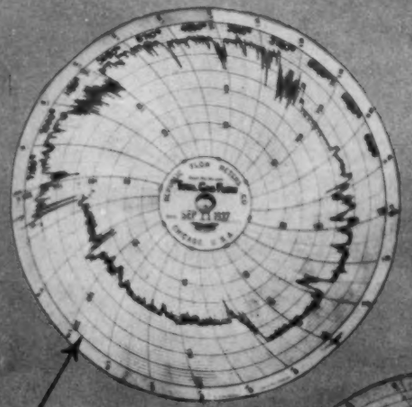
FIGURE 14—PERFORMANCE DATA

	PEAK MONTH		PEAK DAY	
	Boilers Fired With		Boilers Fired With	
	Gas Only	Gas and Coal	Gas Only	Gas and Coal
Boiler Hours Operated	1372	1426	48	48
Ave. Output Lbs. Steam per Hour	128,000	141,000	138,000	164,000
Ave. Steam Pressure	255 Lbs.	255 Lbs.	255 Lbs.	255 Lbs.
Ave. Steam Temperature—Deg. F.	676	682	700	690
Ave. Feedwater Temperature—Deg. F.	220	220	220	220
Ave. C.F.M. Blast Fce. Gas (Standard)	36,400 CFM	32,600 CFM	39,100 CFM	29,100 CFM
Ave. Lbs. Coal per Hour	None	2,660	None	6,350
% Fuel Input as B. F. Gas	100%	84.6%	100%	67.2%
Ave. Overall Efficiency	75.6%	79.0%	77.0%	82.5%
Ave. % Excess Air	9.5%	12.3%	9.2%	15.1%
Ave. Preheated Air Temperature—Deg. F.	468	454	485	438
Ave. Temp. Waste Gases—Last Pass—Deg. F.	740	758	781	768
Ave. Temp. Waste Gases—Lvg. A. H.—Deg. F.	456	438	491	420
B. F. Gas Characteristics				
Moisture Content—Gr. per cu. ft.	27.4	27.4	29.5	29.5
BTU./cu. ft. as fired	89.0	89.0	89.5	89.5
Dust Content—Gr./cu. ft.	0.15	0.15	0.15	0.15
Coal Characteristics				
BTU./Lbs. as fired	—	11,995	—	11,995
Percent through 50 Mesh	—	99.3%	—	99.0%
Percent through 200 Mesh	—	76.5%	—	68.5%

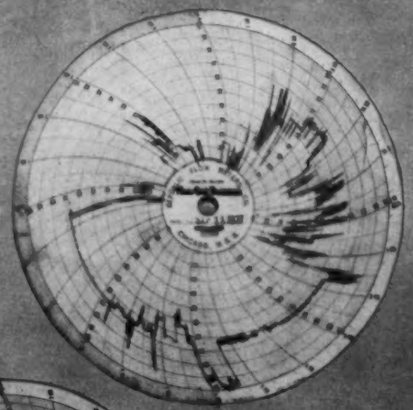
BOILER HOUSE TOTALIZING METER CHARTS



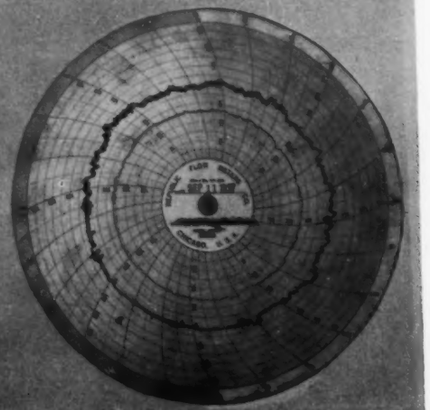
Total House Steam Output
(Thousand Lbs. per Hour)



Total House B. F. Gas Consumption
(Thousand-C. F. M.)

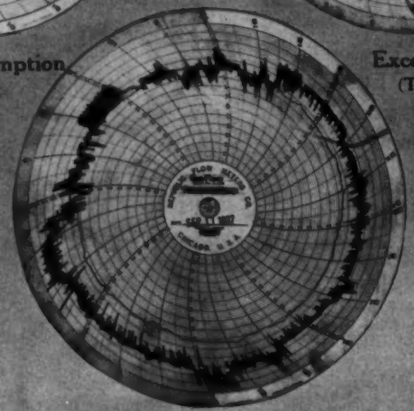


Excess B. F. Gas Bled
(Thousand-C. F. M.)



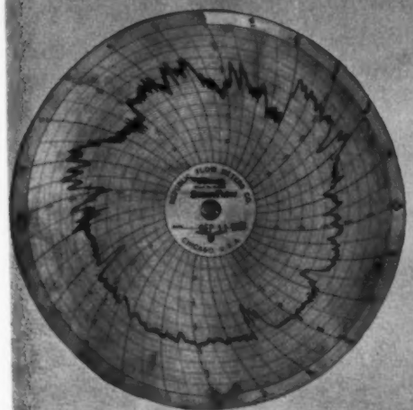
House Steam Pressure and Temp.
(Gage Lbs./Sq. In. and Degrees F.)

Note—Figures in Margin
Show Coal Fired in Lbs.
PER HOUR

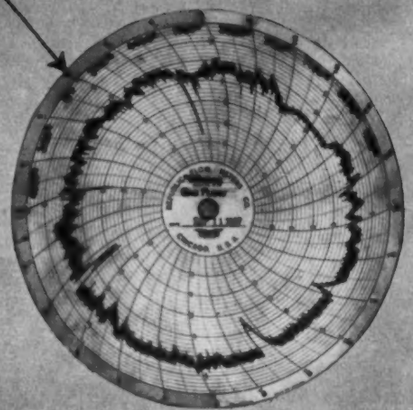


Blast Furnace Gas Pressure
(0-15 Inches Water)

Individual Boiler—Dual Fired

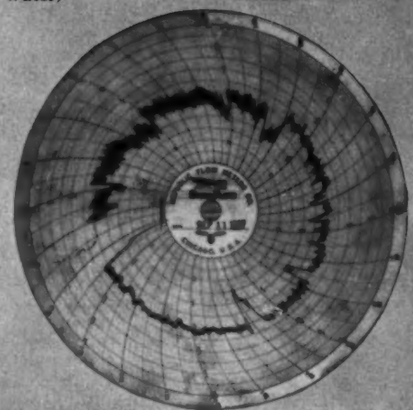


No. 8 Boiler Steam Output
(Thousand Lbs. per Hour)

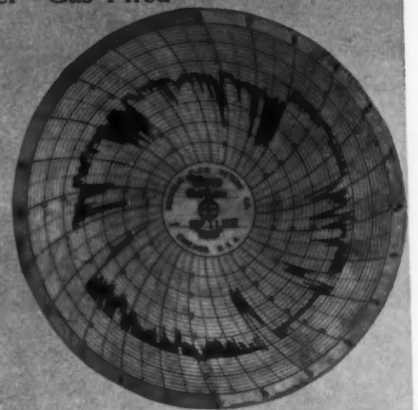


No. 8 Boiler B. F. Gas Consumption
(Thousand-C. F. M.)

Individual Boiler—Gas Fired



No. 7 Boiler Steam Output
(Thousand Lbs. per Hour)



No. 7 Boiler B. F. Gas Consumption
(Thousand-C. F. M.)

(Note: All charts read approximately in units as indicated although correction factors must be applied to all flowmeters for temperature and pressure correction and in some cases for gage calibration.)

All charts start at around 11:30 P.M. Friday night. On the 12 to 8 turn, 11 of the 17 district finishing mills were operating, as well as 5 blast furnaces, both blooming mill groups and the Open Hearth and Bessemer plants. Note the low load periods from 2 to 3 A.M., around 6:30 A.M. and 7 to 8 A.M. With total steam output down, coal was cut-off, gas flow cut back, the gas pressure rose due to the excess and the main bleeder opened to maintain the maximum gas pressure setting. During the balance of this turn gas was utilized completely and coal was fired to maintain the load balance. The greater output from the combination fired boiler illustrates the higher load carrying capacity on coal due to the lower volume and temperature of waste gases requiring less induced draft fan capacity which is the limiting factor in output.

About 7:30 A.M. finishing mills start tapering off in load and were all shut down at 8:00 A.M. Simultaneously one of the two turbo-generators and all gas power engines were shut down due to decreased electric power requirements. Note the definite drop in total steam output and total gas consumption which follows; also the increase in gas main pressure and gas bled when consumption fell off in boilers and engines. The drop in individual boiler output does not materialize since one of the four boiler units was taken off the line at 8:00 A.M. for internal and external inspection. The effect of the strip mill electric load as transmitted to the boilers through the turbo-generator steam requirement is very prominently illustrated by the change in character of steam flow charts before and after 8:00 A.M. Note also that the instantaneous steam flow fluctuations were more severe on the gas fired boiler which is adjacent to the steam takeoff than on the combination fired boiler which is further removed from this point and in which the superheater pressure drop is greater. The effect on the flash capacity of these two boilers is apparent.

From 8 to 9 A.M. is a beautiful illustration of the effect of fan capacity limitation. The 3 remaining boilers were taxed beyond their fan capacities to carry the total load on straight gas. The gas fired boiler was producing its maximum output as limited by the fan. The remaining total steam requirement was beyond the fan capacity of the two combination fired boilers when using all gas available. In order to meet the temporary load conditions it was necessary to manually reduce the gas consumption of the two combination fired boilers to permit the fans to produce the steaming rate required by firing coal. For the balance of this 8-4 turn, the gas consumption and bleed follows the load demand closely, with no coal firing.

At 4 P.M. the two blooming mills went down with the indicated pronounced drop in steam output and increase in gas pressure and bleed. One of the three remaining boilers was simultaneously taken off the line for burner cleanout, resuming at 10:00 P.M. when the gas fired boiler shown was taken off for the same purpose.

DISCUSSION

PRESENTED BY

J. H. STRASSBURGER, Steam Engineer, Weirton Steel Company, Weirton, W. Va.

W. T. McCULLOUGH, Babcock & Wilcox Company, Pittsburgh, Penna.

J. H. STRASSBURGER: The paper just given by Mr. Williams describing the design and operation of the new boiler plant at the Ohio Works was very interesting and the information will be of value to the steel industry.

As a matter of interest we will describe the 800-Lb. topping plant installed at Weirton at about the same time that the Ohio Works' installation was made.

800-LB. PRESSURE 10,000 KW TOPPING TURBINE GENERATOR INSTALLATION AT WEIRTON STEEL COMPANY, WEIRTON, W. VIRGINIA

Early in the year of 1934 the power demands at Weirton reached a point that indicated a sizable increase must be made to the steam and power generating plants in order to cope with the increasing demand for power created by the greater proportion of finished steel produced in the lighter gauges. The development of WEIRITE, a cold rolled tin plate product of high ductility displacing the old pack hot rolled product, was a large factor in the greater demand for power. A study was then made to determine the best solution to this problem, taking into consideration the various factors involved which were briefly as follows:

1. That the entire power demand of the Weirton Plant was being generated and there was no outside power supply.
2. The power at that time was being generated in two stations:
   (a) The larger of the two stations operating at 215-lb. pressure and 100° F. superheat with five 7500 KW turbine generators available for service. This plant was making the bulk of the power requirements and was operating at a high load factor (amounting to 80% rated load over a twenty-four hour period with 8500 to 9000 KW peaks per generator). This plant was approximately ten to fifteen years old and was still maintaining an operating and thermal efficiency close to that for which it was originally installed.

   The boiler plant located adjacent to this

power house consisted of thirty-five boilers designed for steam conditions of 225-lb., 500° F. Part of these boilers were fired with coal using both pulverizers and underfed stokers. However, a large amount of steam was being generated with by-product fuels and waste heat such as blast furnace gas, coke braize and open hearth waste heat, so that any addition to this plant must take these factors into consideration so that no wastage of available by-product fuels would occur. This boiler plant was being operated at the maximum steaming rate and every possible pound of steam was being produced in order to handle the large demand required for power as well as process and mechanical drives. The equipment in this plant was in good physical condition, although the shortage of steaming capacity was a serious problem.

(b) The smaller of the two power plants consisted of two 3,000 KW, 150-lb. turbo generators with three 1,000 KW mixed and low pressure turbo generators. This plant was connected electrically to the larger plant but there was no steam tie-in between the two plants. This generating station had been maintained in good operating condition and could be considered to be of value in any plant extension as a standby station. The boiler plant connected with this smaller power house was approximately twenty-five years old and had reached a stage where expensive boiler rebuilding was necessary. This steam plant also had a large demand for steam for process and mechanical drives.

3. The available water supply for the boilers consisted of 100% treated make-up inasmuch as all the condensers in the plant were of the barometric type.

In analyzing this problem, it was decided to continue with the generation of the entire power supply for the plant because of the large investment already made in the generating equipment and an available operating personnel trained for handling the power requirements. The addition of greater capacity was logical as the increased capacity could be installed with considerable operating savings, whereas the use of purchased power would have an adverse effect on power generating costs of the existing plant. This analysis also showed that it was advisable to install sufficient steam capacity at the 225-lb. station so that the older 160-lb. boiler plant could be dismantled and a steam tie-in installed between the 225-lb. plant and the 150-lb. consuming units.

STEAM CONDITIONS

The question of steam conditions for the new plant was analyzed to determine whether the extension should be made on the existing 225-lb. pressure or whether a higher steam pressure would be of advantage. The extension of the existing 225-lb. plant required a large increase in steam generating capacity and would add very little toward the improvement of the overall efficiency of the power plant. The use of a superimposed turbo generator set-up was considered and a study made of both an 800-lb. and 1200-lb. steam pressure at the turbine throttle. Approximately 25% more steam generating capacity was required for the 800-lb. set-up as compared with the 1200-lb. plant but the investment cost of the 800-lb. and 1200-lb. plant was approximately the same for an identical electrical capacity. The decision was made to install the 800-lb. set-up for the following reasons:

1. The greater amount of steam required for a given power generation was a distinct advantage in making available sufficient 225-lb. exhaust so as to completely displace the 160-lb. boiler plant.
2. The decision to use treated water for the high pressure boilers made the installation of the 800-lb. plant more advisable than the 1200-lb. plant because more operating experience was available for the 800-lb. pressure using treated water. This proposed plant was to be operated on 100% make-up feedwater and available experience in plants operating at 600-lb. to 800-lb. pressure was considered to be of sufficient value to substantiate the use of this type of feedwater for the new plant.

ADVANTAGES OF SUPERIMPOSING

The superimposed boiler and turbine plant had many advantages over the extension of the existing 225-lb. system and made it possible—

1. By the addition of a single 10,000 KW back pressure turbine generator exhausting at 215-lb., 540° temperature to increase the overall efficiency of the entire power generating set-up so that the water rate for the plant be reduced to 70% of the original existing plant. This reduction in water rate was made possible due to the fact that the back pressure turbine generator extracted less than 10% of the heat of the steam passing through it and actually required an equivalent of approximately one-third of a pound of coal per KWH. Therefore, the installation of this single unit lowered the water rate on the plant so that it was fairly well in line with central station practice and in the future, the addition of the second generator would still further reduce the overall water rate of the plant so that the combined new and old units would be operating on a high thermal efficiency.
2. The installation of a back pressure turbine required no additional condensing water supply.
3. The extended plant had to be capable of handling large swings in power and so arranged that the steam generating equipment of the new plant would take the major portion of the change in load, because with the installation of the high pressure boilers and the available 215-lb. steam from the turbine exhaust, the amount of coal firing required on the old boilers would be reduced to a minimum and the by-product fuel and waste heat firing remaining, would not be

conducive to carrying changes in load. The superimposed turbine offered a very good solution to this problem inasmuch as every kilowatt generated on the high pressure unit exhausted sufficient steam at 215-lb. pressure to generate an additional two kilowatts on the lower pressure condensing turbine generators. As an example of this—a swing of 3,000 KW on the topping turbine would exhaust sufficient excess steam to produce an additional 6,000 KW on the old generators, so that a total swing of 9,000 KW would be possible without the lower pressure boilers changing steaming rate. This characteristic of the topping turbine has worked out in practice to handle swing loads as contemplated and has actually been a stabilizing governor on both the electric and steam plants.

W. T. McCULLOUGH: Mr. Williams' paper describes the successful operation of an installation designed and built to meet the most difficult set of conditions to be found in the entire power generating field.

The description of the automatic control system brings out—The variation in fuel from 90 B.T.U., B.F. gas to pulverized coal using unit mills. The great variation in load due to strip mill and other peak load steel mill apparatus which takes place without any relation to the fuel which may be available—the various steam pressures and temperatures to be maintained on older equipment. Much credit is due to those who are responsible for the design and operation of this installation.

From the boiler furnace standpoint it is interesting to note no change in the trend of combining blast furnace gas and pulverized coal firing in the same furnace as described by Kerr in his paper at the Pittsburgh meeting in 1930. Also while unit mills have been substituted for Bin systems, the same type B.F. gas and pulverized coal burners have been installed as have proved so successful at T. C. & I.

The single pass baffling is to be noted giving a draft loss through the boilers of .7″ and 2.3″ with coal and B.F. gas respectively at same 400% rating. A total draft loss through the entire unit of 2.9″ and 9″ with coal and B.F. gas respectively at 400% rating.

The purity of the steam with widely swinging loads has also been provided for as is shown by the drum sizes and locations and finally by the installation of steam scrubbers so that steam conditions are no longer being discussed in terms of so many percent moisture but in terms of 1 p p m or less with 70% make up feed water and capacity of 450 to 500% of rating.

Feed water has also received careful consideration and proper deareation is provided.

Truly this power plant represents one of the outstanding Steel Mill installations in the United States, and the paper will well repay careful study.

A. I. & S. E. District Section Activities

CHICAGO SECTION

November 16, 1937—6:15 P.M.

Phil Smidt's Restaurant
1170 Indianapolis Blvd.
Roby, Indiana

"Direct Current Power Supply for Steel Mill Applications" by C. C. Herskind, Power Rectifier Engineering Department and W. B. Snyder, Steel Mill Section, Industrial Department, General Electric Company, Schenectady, N. Y.

H. W. NEBLETT, Chairman
A. J. WHITCOMB, Secretary

CLEVELAND SECTION

Monday, November 8, 1937—8:00 P.M.

Electric League Auditorium
Midland Building

"A Ramble Through Steel Mills in England and Europe" by Earl C. Smith, Chief Metallurgist, Republic Steel Corp., Cleveland, Ohio.

Added Feature: Movies of Cleveland Section Golf Party held at Youngstown Country Club, September 17, 1937.

T. J. ESS, Chairman
W. W. SPANAGEL, Secretary

BIRMINGHAM SECTION

November 29, 1937—6:45 P.M.

Thomas Jefferson Hotel

"Diesel Electric Locomotives" by H. L. Hamilton, President, Electro-Motive Corp., subsidiary of General Motors Corp., La Grange, Ill.

R. R. THOMAS, Chairman
BIRGER THELE, Secretary

PITTSBURGH SECTION

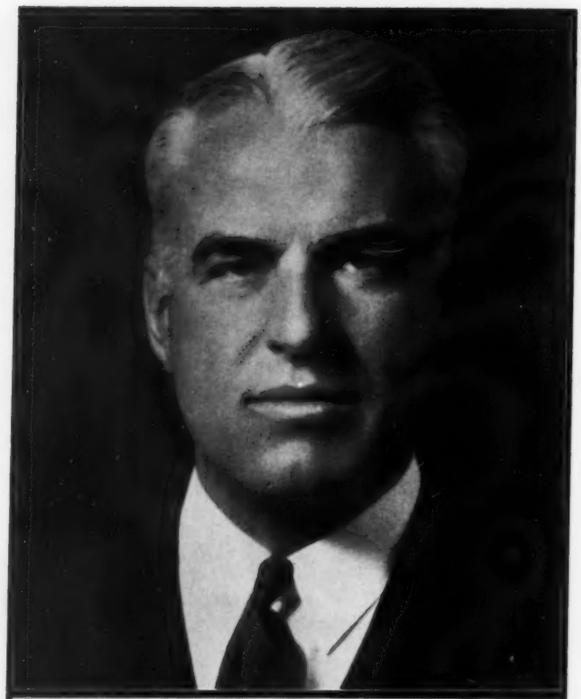
November 26, 1937—8:00 P.M.

Ball Room—Wm. Penn Hotel

George E. Sokolsky, noted author and commentator will speak on "Economic Trend and Management's Job in Bringing About and Maintaining Satisfactory Employer-Employee Relations."

An informal dinner at 6:30 P.M. will precede this lecture. Price $1.50 per person.

UNITED STATES STEEL



EDWARD R. STETTINIUS, JR.

Late last month the United States Steel Corporation issued an announcement, which showed important changes in the administrative personnel of the largest industrial organization in the present-day world.

Edward Riley Stettinius, Jr., who will succeed to the top post vacated by Myron C. Taylor, like his predecessor is also a financial expert, having held the post of chairman of the Finance Committee.

Son of the late Edward Riley Stettinius, a former partner of J. P. Morgan and Company, Mr. Stettinius was educated at the University of Virginia. He entered the General Motors Corporation in 1924, with the Hyatt Roller Bearing Division. He worked his way up to the vice presidency by 1931, and in 1934 went with the United States Steel Corporation as vice chairman of their finance committee. On January 1, 1936 he was elected chairman of that committee, and a director of the corporation.

The thirty-seven year old chairman of the board is also a director and vice president of General Aviation Corporation, a director and member of executive committee of North American Aviation, Inc., a director and member of the executive committee of Transcontinental and Western Air Express, and a director of Eastern Air Transport. He was also in charge of several Government activities during the years 1931 and 1932.

▲

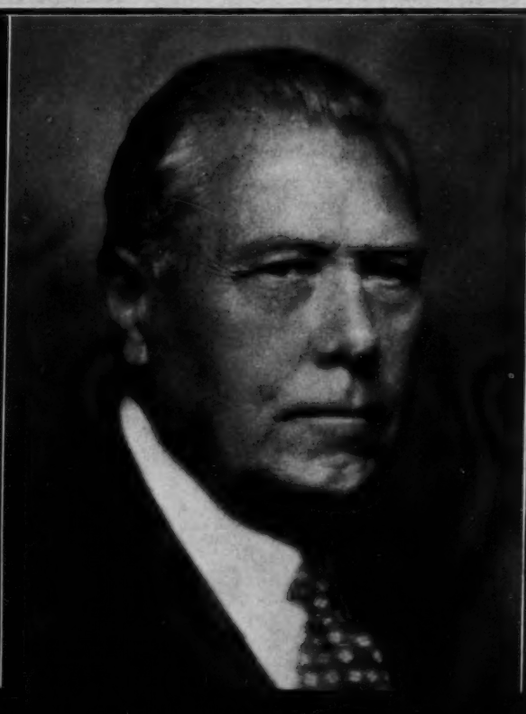
Benjamin F. Fairless will be moved from the presidency of the Carnegie-Illinois Steel Corporation to succeed William A. Irvin, as president of the United States Steel Corporation.

Born May 3, 1890, in Pigeon Run, a small coal mining village near Massillon, Ohio, Mr. Fairless attended school at Justus, Ohio, and then, by teaching school at Rockville, and Navarre, Ohio earned enough money to enroll at Wooster (Ohio) College. He transferred to Ohio Northern University where he was graduated with a civil engineering degree. A few years ago this school conferred upon him the honorary degree of doctor of engineering.

Mr. Fairless began his engineering career with the Wheeling and Lake Erie Railroad, as a civil engineer. Becoming interested in the manufacture of alloys, he went with the Central Steel Company, Massillon, Ohio, as a civil engineer advancing rapidly to mill superintendent, and vice president in charge of operations. In 1926, following the merger of United Alloy Steel Corporation and Central Steel Company to form the Central Alloy Steel Company, Mr. Fairless was made vice president and general manager of the combined companies, a position he held until becoming president in April 1928. A series of other mergers, which precipitated in the dominence of Republic Steel Corporation, found him as executive vice president of that corporation.

B. F. FAIRLESS

MYRON C. TAYLOR



E. M. VOORHEES

EERSONNEL CHANGES

In September 1935, he was chosen to head the newly organized Carnegie-Illinois Steel Corporation, which had been formed by the Carnegie Steel Company, the Illinois Steel Company, and the Lorain Steel Company. He held this position until the United States Steel Corporation selected him as their chief executive.

▲

Myron C. Taylor resigns as Chairman of the board of the United States Steel Corporation. He will continue in an advisory capacity as a member of the finance committee, and a director of the corporation.

Mr. Taylor was born sixty-three years ago at Lyons, New York. He attended Lyons Union School, and later the National Law School in Washington, D. C., completing his education with a final year at Cornell Law School, where he was a pupil of Charles Evans Hughes. In 1894, he was graduated at the age of twenty, a feat possible because he had gone directly from secondary to law school. On his twenty-first birthday he was admitted to the New York bar.

Mr. Taylor, who has spent his entire business life administering the finances of various corporations, went with the United States Steel Corporation in 1927, as chairman of finance committee. In 1932, Mr. Taylor became chairman of the board and chief executive officer, which position he held throughout the depression. It was through his efforts that the great steel corporation weathered the storm, of the depression years, with flying colors.

▲

Enders M. Voorhees will succeed Edward R. Stettinius, Jr., as chairman of the Finance Committee. He was born forty-five years ago in Amsterdam, New York, where he attended high school. In 1914, he was graduated from Dartmouth College.

Mr. Voorhees began his career with Hollis H. Sawyer and Company, of Boston, later going to Manila, Philippine Islands with the Pacific Commercial Company, an exporting and importing firm. This was followed by three years with the United States Rubber Company in New York. Before joining Johns-Manville, Mr. Voorhees was engaged in industrial engineering for William A. Harriman and Company, and Sanderson and Porter. While with Johns-Manville he successfully was auditor, treasurer, secretary, vice president, and a director. After nine years with the Johns-Manville Corporation he was elected vice chairman of the finance committee, the position he held until his present appointment.

William Adolph Irvin, president of the United States Steel Corporation since 1932, will retire December 31 to serve in an advisory capacity, and as vice chairman of the board. Mr. Irvin has been in the steel business since 1895. He was born December 7, 1872, in Indiana, Pennsylvania, where he received a public school education, supplemented by night study.

In 1888 he joined the Pennsylvania Railroad as a telegraph operator. In 1895, he went to work for P. H. Laufman Company, Ltd., manufacturer of sheet and tin plate. This company (along with Mr. Irvin) was taken over in 1900 by American Sheet Steel Company. In 1904 this company was merged with American Tin Plate Company, and the offices were transferred to Pittsburgh, where Mr. Irvin was made assistant to the operating vice president. In 1931, he was made vice president of the United States Steel Corporation, and six months later elevated to the presidency.

▲

John L. Perry, the new Carnegie-Illinois Steel Corporation's president, succeeds Benjamin F. Fairless. Mr. Perry was born March 11, 1881, in Worcester, Massachusetts. He was educated in the grade and high schools of Worcester.

Mr. Perry began his business career in August 1899, when he entered the service of American Steel and Wire Company, and after serving in various capacities he was appointed, in 1925, assistant manager of the Worcester district. He became manager of that district three years later. January 1, 1933 he was elected vice president in charge of operations of the American Steel and Wire Company (which by that time had become a subsidiary of the United States Steel Corporation) with his headquarters in Cleveland, Ohio.

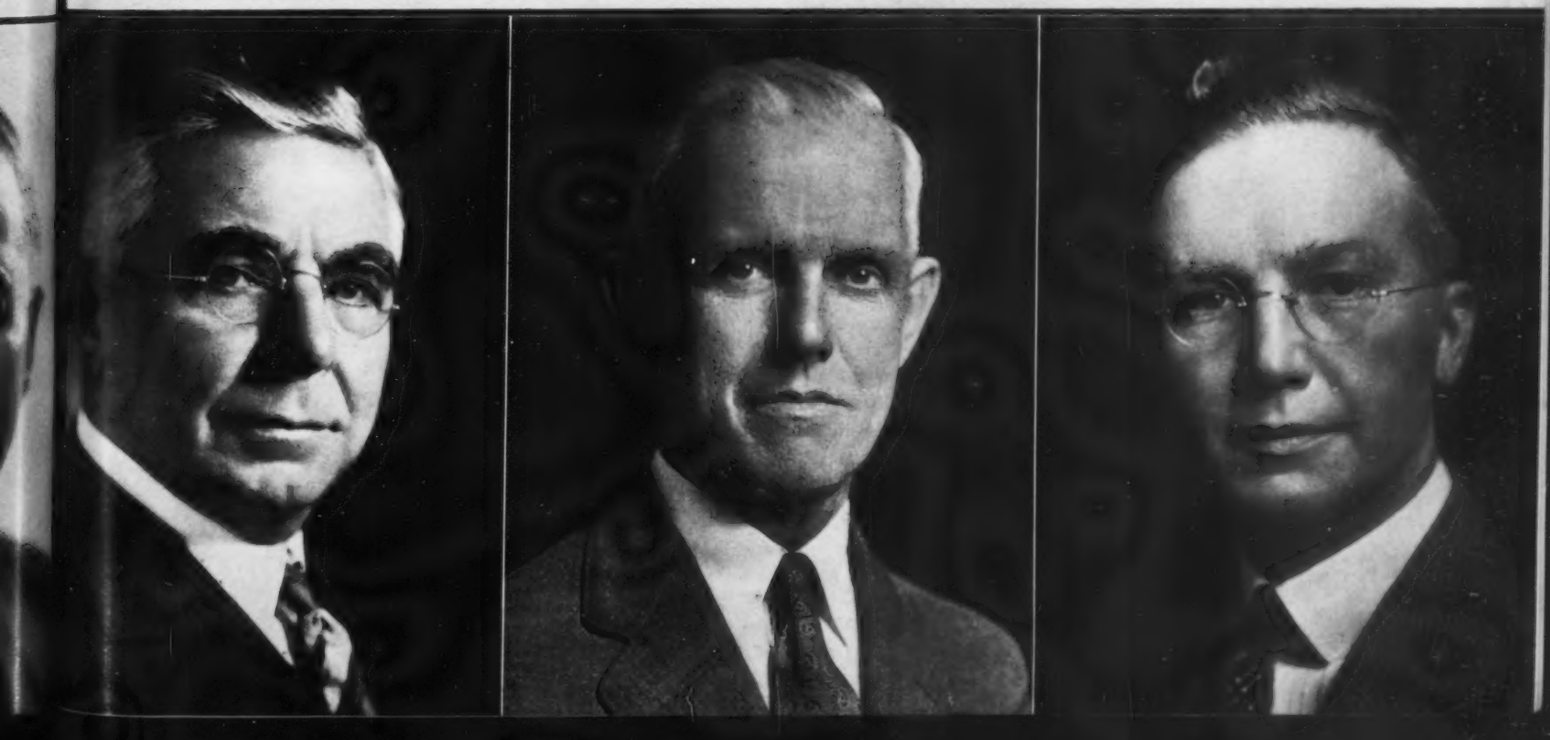
On February 1, 1935, he was elected president of the Tennessee Coal, Iron and Railroad Company, Birmingham, Alabama, a post he held until his recent election as president of the Carnegie-Illinois Steel Corporation. Like Mr. Fairless, Mr. Perry is an operating man. He is expected to make his headquarters in Pittsburgh, the home office of the Carnegie-Illinois Steel Corporation.

▲

Robert Gregg, fifty-two, will become president of the Tennessee Coal, Iron and Railroad Company succeeding John L. Perry. Mr. Gregg, whose headquarters have been in New York, is a director and commercial vice president of the United States Steel Corporation, director of Carnegie-Illinois Steel Corporation, Columbia Steel Company, and Scully Steel Products Company.

Before joining the United States Steel Corporation, Mr. Gregg was president of the Atlantic Steel Company of Atlanta, Georgia. From there he went with the Tennessee Coal, Iron and Railroad Company becoming president. He was later transferred to the vice presidency in charge of sales for the United States Steel Corporation

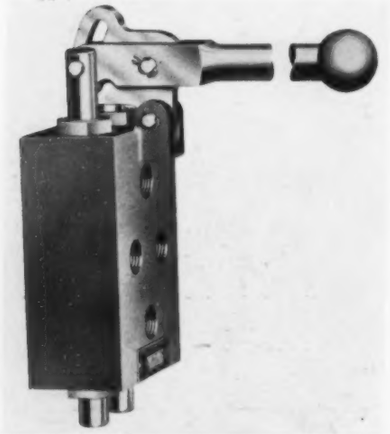
WILLIAM A. IRVIN **J. L. PERRY** **ROBERT GREGG**



NEW HYDRAULIC PRESSURE VALVE

▲ C. B. HUNT and Son's Company, Salem, Ohio, has added to their line of valves a new hydraulic valve, in two types, for 1000 pounds working pressure and 2000 pounds working pressure. The valve housing is machined from a solid steel slab. It is made in 2-way, 3-way, and 4-way. The 3-way and 4-way valves have only two internal parts for valving action which operate to completely eliminate metal-to-metal wear. Sizes from ½" to 1½" are available. This new unit is designed so that piping connections may be made either above or below. For inspection, piping connections need not be disturbed. Entire valving assembly and cylinder or leverage can be removed and replaced in a few minutes. Valves are tested for any extremes possible for their working pressure ratings.

Hydraulic valve made in 2 way, 3 way and 4 way, for 1000 and 2000 pounds working pressure.



MODERNIZATION PLANS ANNOUNCED BY FORD

▲ THE Ford Motor Co. has recently purchased 45,000 tons of steel to be employed in construction of a new foundry and other plant additions.

Pennsylvania Engineering Co. has contracts for the rebuilding of four of the nine Ford open-hearth furnaces, with contracts not yet awarded for the remaining five. Contracts for the new bessemer converters are understood to be pending.

Arthur G. McKee & Co., Cleveland, have been awarded contract for the proposed 1200-ton all-welded blast furnace to be constructed at the Rouge plant. This will make the third stack of the Ford group. It is understood that contracts have not yet been let for all the blast furnace auxiliary equipment. The estimated total cost of the stack and the supplemental equipment is placed at $4,500,000.

General Electric Co. is supplying the new 110,000 kilowatt turbo-generator; and Combustion Engineering Co., a division of Superheater Co., the boiler involved in the Ford powerhouse expansion.

The United Engineering & Foundry Co. has the contract for the additions to the rolling and finishing mills, including equipment to roll 60-inch sheets, and a new hot finishing stand. Rust Engineering Co. is installing one of the new slab reheating furnaces, while contract has not yet been let for the second.

For the cold finishing mill, Westinghouse Electric & Mfg. Co. is furnishing 12 sets of three bell-type bright annealing electric furnaces; and Wean Engineering Co. has the contract for the proposed 78-inch continuous pickler.

The gas-holders, which have been under construction for several months, are being built by Stacy Bros. Construction Co. and Bartlett-Hayward Co.; and the new battery of 61 coke ovens, also under construction, is being installed by the Koppers Co.

BLAW-KNOX COMPANY CONSOLIDATES SUBSIDIARIES

▲ WILLIAM P. Witherow, president, Blaw-Knox Company, announced that action had been taken by the company's board of directors affecting a change in the corporate relationship of its domestic subsidiaries.

Effective November 1, 1937, the subsidiaries of the Blaw-Knox Company will be known as Divisions of Blaw-Knox Company, and the fabricating division located at Blawkox, Pa., will be known as the Blaw-Knox Division of the Blaw-Knox Company.

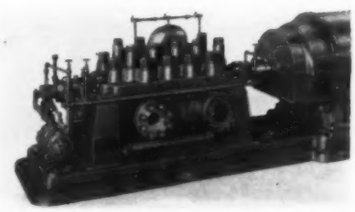
Officers of the former subsidiaries will retain their respective status, and

their duties will continue as they were under the former arrangement.

"This action has been taken by the company," states Mr. Witherow, "to simplify and strengthen the corporate structure and to effect certain economies".

MULTI-STAGE HIGH PRESSURE PUMP

▲ ALLIS-CHALMERS Manufacturing Company, Milwaukee, Wisconsin, has recently introduced an improved design of multi-stage pump into the high pressure pump field. This pump is called the "Doubleton" type because of the use of double suction impellers, and the double balance of the rotating element. The double suction impellers provide axial balance and the positions of the successive volute passages which surround each impeller are made so as to largely equalize unbalanced radial forces on the impellers. These pumps



Multi-panel high pressure pump for such applications as descaling pumps in steel mills, boiler feed service.

are made with horizontally split casings for pressures 1500 lbs. and above. The design and bolting has been so worked out, based on the Company's experience with bolting high pressure, high temperature steam turbine casings, that no difficulty is experienced in maintaining a tight joint and retaining the advantages of the split casing construction. This pump is suitable for high pressure applications such as "Descaling" pumps in steel mills, boiler feed service, oil pipe line pumps, etc.

NEW IRVIN WORKS COMPLETED—IN MINIATURE

▲ THE giant new Irvin Works of Carnegie-Illinois Steel Corporation has been completed—in miniature.

A plaster model of the continuous hot strip mill, now under construction near Pittsburgh, Pa., has been made for the convenience of the company's construction engineering bureau. The model, correct in dimension on a scale of 100 feet to an inch and showing all the buildings and contour of the site, is four feet wide and six and one-half feet long. In the accompanying picture the length of the buildings represents about one mile.

The model weighs about 600 pounds. It was cast in three sections and then assembled in the engineering offices of the Carnegie Building in Pittsburgh where it provides engineers with a clear picture of the way the plant will look when completed.

The buildings of the model are removable to show equipment. The equipment has been painted brown to distinguish it from the rest of the model.

The model was completed in about two months.

UNIQUE TANK DESIGN FOR PICKLING UNIT

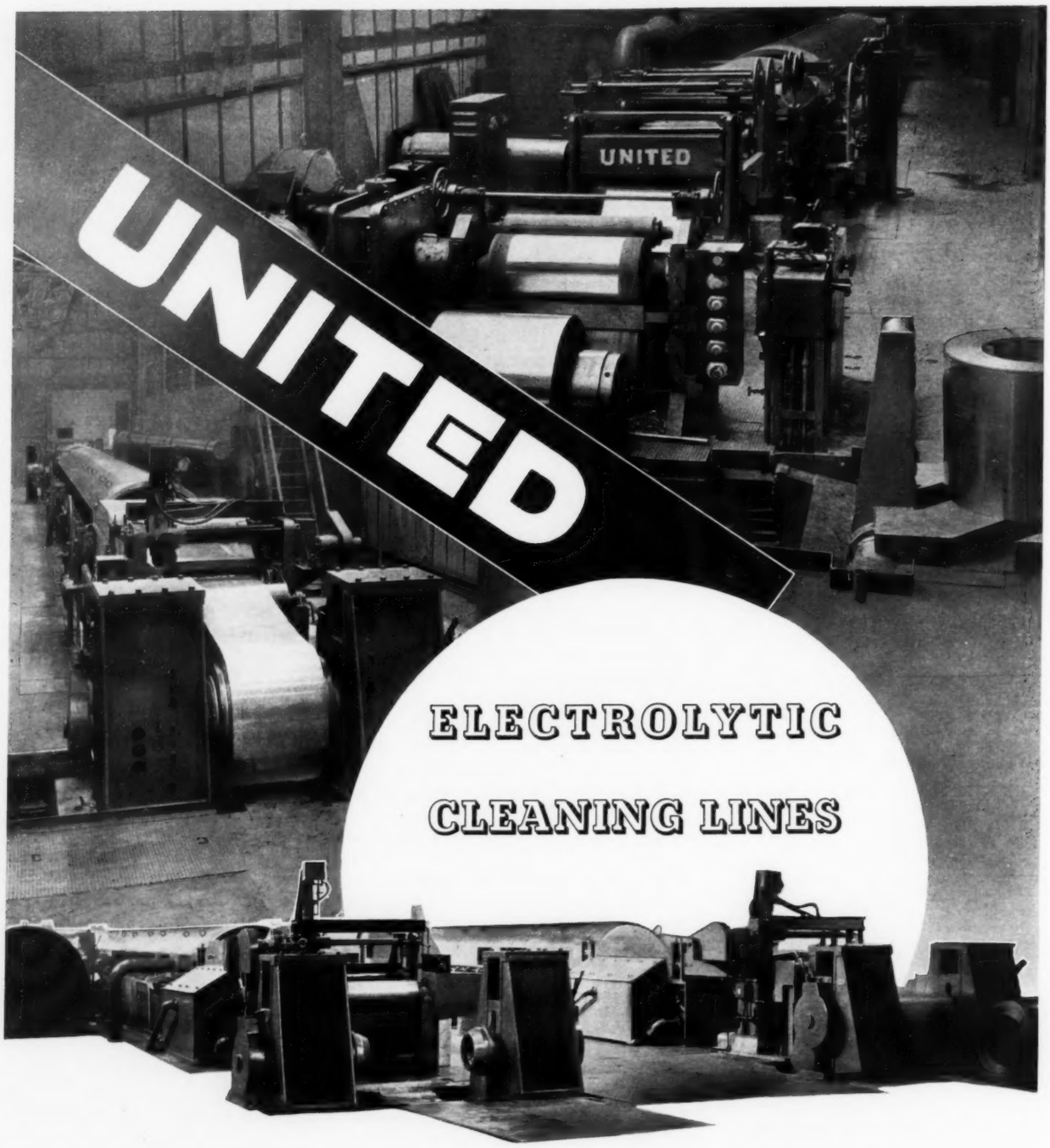
▲ SINCE the continuous strip sheet pickler is a comparatively new development in the steel industry, companies are frequently faced with the problem of fitting this equipment into a limited space to avoid the necessity of making costly plant additions.

Such was the case at one large mill where the space between the existing buildings housing the coil storage and cold rolling departments made it impossible to install a pickling unit of standard length.

The problem was solved satisfactorily, however, by means of a unique tank design. Instead of using four separate pickling tanks, a single steel tank approximately 200 feet long was made up in five flanged sections and assembled on the job. This tank was lined with ¼" Triflex rubber by The B. F. Goodrick Company and then sheathed inside with 8" brick jointed with sulphur base cement. Then by installing brick partitions the interior of the tank was divided into four separate acid compartments, each measuring approximately 50 feet long x 100 inches wide x 4 feet deep.

The steel strip is carried on 12"

A single steel pickling tank, 200 feet long made up in five flanged sections and assembled on the job.



UNITED
ENGINEERING and FOUNDRY COMPANY
PITTSBURGH — PENNSYLVANIA

High speed operation . . . accuracy . . . ease, and flexibility of control . . . and cleaner strip. These are the outstanding features of the new and improved UNITED Electrolytic Strip Cleaning Lines. Sixteen are now in operation or under construction.

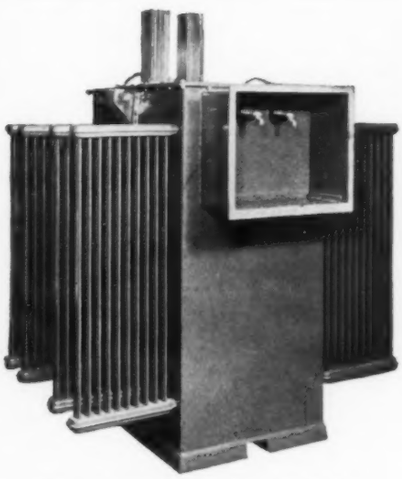
ASSOCIATED COMPANIES: DAVY AND UNITED ENGINEERING COMPANY, LTD., SHEFFIELD, ENGLAND DOMINION ENGINEERING WORKS, LTD., MONTREAL, P. Q.

diameter rubber-covered rolls which are mounted on tank at ends and over each partition. Tank covers and fume ducts are of Triflex-lined steel construction. Each acid compartment is equipped with a combination syphon and overflow device which maintains proper liquid level at all times.

Separate rinse tanks of similar design, equipped with 22″ diameter rubber-covered hold-down rolls complete the installation. The whole unit is housed compactly in a specially designed building equipped with monorail crane to handle cover sections and rollers.

TRANSFORMERS FOR ELECTROLYTIC SERVICE

▲ R. E. UPTEGRAFF Manufacturing Company, Pittsburgh, Pa., has just completed a special Transformer designed and built for electrolytic service. It delivers 15,000 amperes from the secondary. The low voltage terminals consist of ten ¼″ x 6″ bus bars.



Transformer designed and built for electrolytic service.

This newest transformer from the Uptegraff plant is an indication of this manufacturer's facilities in building transformers for heavy currents, as well as for high voltage, and in designing transformers for special application.

FOREIGN AND DOMESTIC ORDERS ANNOUNCED

▲ A GROUP of mill equipment orders from foreign and domestic sources was announced by the United Engineering & Foundry Co.

The company has received from Machinoimport of U. S. S. R. a contract to supply complete 112-inch hot and cold 4-high reversing mills, a 66-inch 4-high reversing mill, a 112-inch and a 66-inch planishing mill with auxiliary equipment. There is also a complete finishing department, including cleaning, shearing, leveling and processing equipment. The machinery will be shipped within one year.

United Engineering also has closed with the Youngstown Sheet & Tube for a new high-speed 2-stand 4-high 42-inch wide tandem skin pass mill for cold reduced tin plate in coil form, and an electrolytic cleaning line for processing this material. This equipment will be installed in the Indiana Harbor, Ind., plant of Youngstown Sheet & Tube.

Through the H. A. Brassert Co., consulting engineers of Chicago, United Engineering has received orders for two 4-high reversing cold mills and three 2-high skin pass mills from Stewart's and Lloyds' division of Lancashire Steel Corp. of Corby, England.

Through their Canadian associates, Dominion Engineering Co., Ltd., United Engineering has sold one of its new rorary coil picklers to Dominion Foundries & Steel, Ltd., of Hamilton, Canada.

United Engineering's associated English company, Davy & United Engineering, Ltd., has sold two of the largest heavy forging presses ever manufactured.

United officials and representatives of "Machinoimport" signing contracts for large mill orders.

NEW PUBLICATIONS

▲ THE Askania Regulator Company of Chicago, Illinois, have recently brought out a new bulletin titled, "Automatic Control for the Steel Industry". The bulletin contains valuable information, usable by engineers in the industry, as it shows practical applications of control equipment to many problems. It describes in complete detail the application of pressure and combustion controls to the soaking pit, open hearth, heating furnace and many other applications.

In addition to the above, engineers will find in condensed form information usable for the calculation of orifice sizes. In these two pages are all

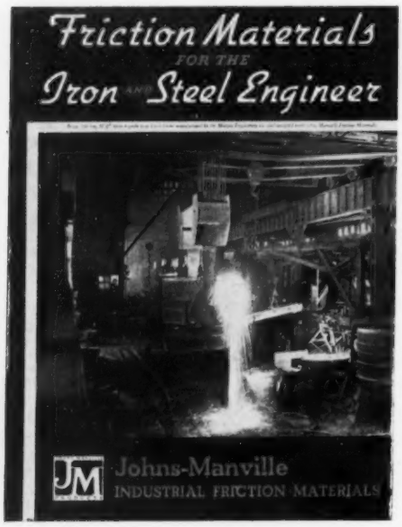
the data necessary to determine the size of an orifice plate for a gas or an air line. This information should

prove of practical interest to engineers making quick calculations in connection with flow problems.

A copy of the bulletin may be had by writing to Askania Regulator Company, 1603 South Michigan Avenue, Chicago, Illinois.

▲ IN a new brochure, "Friction Materials for the Iron and Steel Engineer", Johns-Manville has gathered together in compact form the most comprehensive data published up to the present time on brake linings and clutch facings for steel mill equipment.

The most important feature of this brochure is a chart which simplifies



the selection of the most suitable J-M friction material for every steel mill service. On this chart are represented brakes and clutches of the disc, cone and band types. Listed down one side of the page are all of the factors which must be considered, such as—rubbing speed, drum temperature and pressure. If one knows the service conditions which must be met, he can look them up on this chart and, by glancing horizontally across the page, automatically pick out the correct friction material for his purpose.

Supplementing this technical chart is a second table which gives the coefficient of friction, size limits, thickness, tolerances and recommended service conditions for each of the various types of J-M Industrial Brake Linings and Blocks, and Friction Facings.

Copies of this brochure, Form FM-6A, are available upon request to Johns-Manville, 22 East 40th Street, New York City.

ARMCO DEDICATES NEW LABORATORIES

▲ MORE than 200 scientists from all parts of the country were guests of The American Rolling Mill Company at the dedication of Armco's colorful new research laboratories in Middletown, Ohio, on Friday, November 5.

"Research is what keeps industry healthily dissatisfied with itself", was the keynote of the dedicatory address by Charles F. Kettering, vice-president in charge of research of General Motors Corporation, at the banquet that concluded the day's activities.

George M. Verity, chairman of the board of Armco, told his audience that "from the courage and brains of men who have refused to accept today's products as representative of 'perfection' has come the impetus that has given us the highest standard of living known in the world, and which has provided profitable investment for savings of the nation and work and more abundant opportunities for millions of men".

Charles R. Hook, president of Armco, declared "the real goal of industry is to find new products for old and new uses, so that as industry itself grows, more people will have the jobs and the money to buy these new conveniences. How can we achieve that goal? Research is the key, industry the force that can turn the lock".

During the afternoon, guests inspected the new laboratories. A description of the unique building and a short talk by Mr. Kettering wsere broadcast over a nation-wide N.B.C. network of stations.

Research specialists have termed the new laboratories "the most modern in the industrial world". The building is tradition-breaking in design as well as in the combined application of new and old materials. Perhaps nowhere else in American industry are there laboratories that so completely illustrate a company's own progress in product development.

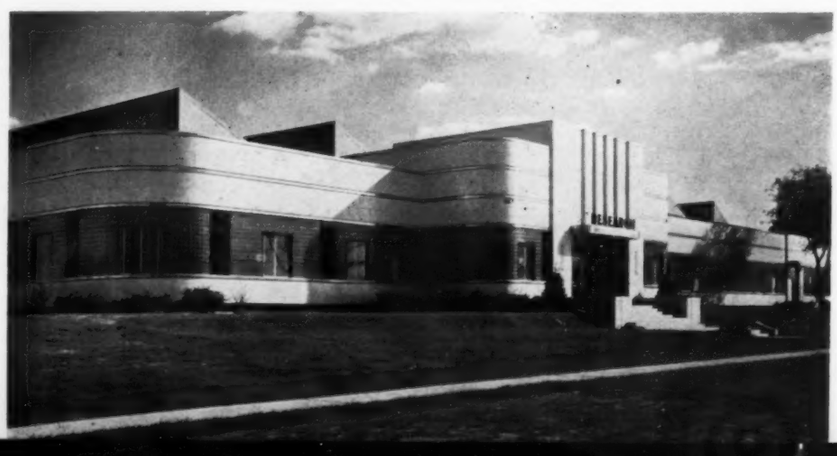
The building, costing $280,000, was erected by The Austin Company in cooperation with Harold Goetz, Middletown architect. A symphony of curves and angles accentuates the modern "streamlined" architectural design. Blended in colorful harmony on the exterior are porcelain enameled iron, stainless steel and glass block.

The single-story research building, with its sweeping lines, resembles silver-striped ribbons of yellow satin with alternate panels of jet and beading in between. It typifies modern industrial design and the role of sheet iron and steel in its application to construction. Although steel walls have been used in filling stations and other small structures, the Armco laboratories represent their first use on a large scale.

There are twelve laboratories with complete facilities for specialized research.

They include equipment for setting up tests to determine and maintain the quality of all Armco products; welding methods with flat-rolled materials; forged steel car wheels; stainless steel; development of corrosion-resistant sheets and strip; iron sheets for porcelain enameling; high-finished sheets for deep drawing; sheets for electrical uses; development of zinc and other metal coatings for sheets; development of non-metallic coatings and the improvement of surfaces to hold these coatings; also for blast furnace, open hearth and electric furnace experiments.

Exterior view of colorful new research laboratories of the American Rolling Mill Company, Middletown, Ohio, dedicated November 5, 1937.



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BANTAM BEARINGS

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ITEMS OF INTEREST

J. L. ("Pete") Mauthe was recently made general superintendent of the Youngstown Sheet and Tube Company's Youngstown district plants. Mr. Mauthe was graduated, in 1913, from the University of Pennsylvania as a metallurgical engineer. He started as a laborer in the Carnegie-Illinois Steel Corporation's Duquesne blast furnaces. Later he worked for the National Tube Company at the McKeesport Works, from there he went to the Gary Works of the Illinois Steel Company becoming assistant superintendent of the coke plant, transferring later to assistant superintendent of the blast furnaces. Returning to the National Tube Company he became assistant general superintendent of the Lorain, Ohio, Works. In 1935 he went with the Youngstown Sheet and Tube Company as assistant superintendent of the Campbell Works, which position he held until his present appointment.

▲

Laurence S. Dahl has been appointed the assistant general superintendent of the Carnegie-Illinois Steel Corporation's Irvin Works, Pittsburgh, Pennsylvania. Experienced in the manufacture of sheet, strip and tin plate, Mr. Dahl goes to his new position from the superintendency of the hot strip mills at Gary, Indiana, Sheet and Tin Division of the Carnegie-Illinois Steel Corporation. Mr. Dahl began his business career in 1924 as a machinist and roll turner, and later worked in the mechanical erection field for several companies. In 1927 he became erection foreman during the construction of a 42-inch mill for the American Sheet and Tin Plate Company and later in the same year was named roll shop foreman. In 1931 he was appointed night superintendent of the 42-inch hot strip mill, and later the same year superintendent of cold reduction and tin mills.

Continuing in various positions of operating responsibility, Mr. Dahl, upon merger of the tin plate company with Carnegie-Illinois in 1936, was named superintendent of sheet mill, cold reduction, annealing and temper mill departments. On April 1, 1937 he was named superintendent of the hot strip mills at the Gary Sheet and Tin Division and continued in that capacity until his most recent appointment.

▲

Stephen M. Jenks has been appointed assistant general superintendent of the Gary Works, Carnegie-Illinois Steel Corporation. Mr. Jenks has been with United States Steel Corporation subsidiaries since July 1925. He began with the American Sheet and Tin Plate Company, now a part of Carnegie-Illinois, as an engineer. He served in various positions in the company's Pittsburgh and Chicago districts until 1936 when the construction engineering division of Carnegie-Illinois was established at Pittsburgh and he was made chief engineer. In February, of this year, Mr. Jenks was appointed chief engineer at Gary Works.

▲

C. P. Kimmel was named assistant to general superintendent of the Gary Works, Carnegie-Illinois Steel Corporation. Mr. Kimmel has served continuously at Gary Works since he began in the roll shop in 1908. He has been the assistant general superintendent of Gary Works since 1918.

▲

Irvin Paul was appointed superintendent of the 80-inch hot strip mills, Gary Sheet and Tin Division, Carnegie-Illinois Steel Corporation, Gary, Indiana. Mr. Paul first went to the sheet mills as a machinist in 1917 and working there continuously since then, has served as shop foreman, erection superintendent and turn foreman of the 80-inch mills, until July 1936 when he was appointed assistant superintendent of the 80-inch hot strip mill, which position he held until his appointment.

J. L. MAUTHE

LAURENCE S. DAHL

STEPHEN M. JENKS

C. P. KIMMEL

IRVIN PAUL

GEORGE H. BAUER

George H. Bauer was made the chief engineer of the Gary Works, Carnegie-Illinois Steel Corporation, succeeding Stephen M. Jenks. Mr. Bauer has been at the Gary Works since 1920, previously, he had spent four years with the Canadian Steel Company. He was made assistant engineer at Gary Works in 1929, and assistant chief engineer in 1934.

▲

Siguard Landen was recently appointed assistant chief engineer of the Gary Works, Carnegie-Illinois Steel Corporation, Gary, Indiana. Mr. Landen, who has succeeded George H. Bauer, began at Gary Works as a draftsman in 1924. In 1934 he was made division engineer, the position which he has held until the present time.

▲

T. R. Miller, former plant industrial engineer at the Gary Works, Carnegie-Illinois Steel Corporation, has been made the assistant division superintendent. Mr. Miller has been with the United States Steel Corporation subsidiaries for thirty-one years. He was superintendent of power for the Minnesota Steel Company from 1918 to 1932, and came to Gary Works in 1934 as a mechanical designer. He joined the industrial engineering department in 1935, and in January 1936 was named as plant industrial engineer in charge of the department.

▲

Walter J. Kirton succeeded T. R. Miller as plant industrial engineer of the Gary Works, Carnegie-Illinois Steel Corporation, Gary, Indiana. Mr. Kirton has been at the Gary Works since 1925, when he began as a test engineer.

▲

Laurin D. Woodworth was recently appointed chief metallurgist of the Youngstown district plants of the Carnegie-Illinois Steel Corporation. Mr. Woodworth, who has been foreman of the metallurgical observation corps at Youngstown since 1931,

SIGUARD LANDEN

T. R. MILLER

WALTER J. KIRTON

began his career with the Pennsylvania Geologic Survey in 1921. He entered the steel industry a year later as a metallurgist, and in 1927 joined the Carnegie Steel Company at the Youngstown metallurgical department. His experience also includes a year in research work in connection with open hearth melting practice under supervision of the United States Bureau of Mines.

▲

Philip Schane, Jr., recently became the chief metallurgist at the Duquesne Works of the Carnegie-Illinois Steel Corporation. Mr. Schane, who was chief metallurgist at Duquesne from November, 1932 until January, 1936, when he went to Youngstown in the same capacity, succeeds James A. Ogilvie, who is no longer with the company. Mr. Schane was graduated in 1926, from the Carnegie Institute of Technology, and has been in the continuous employ of the Carnegie-Illinois Steel Corporation, and its predecessor the Carnegie Steel Company since 1911, when he was employed as a messenger at the Homestead Works.

▲

Edward A. Brown, Jr., was appointed assistant to the general superintendent of the Duquesne Works, Carnegie-Illinois Steel Corporation, Duquesne, Pennsylvania. Mr. Brown, who earlier this year was appointed assistant to the chief engineer in charge of fuel and steam at Homestead Works, began his new duties at Duquesne on November 1. He attended Carnegie Institute of Technology and in 1911 began his career as an engineering department tracer and detailer in the Homestead Works. He later served in various engineering capacities and for the two-year period from 1935 to 1937 had the combined duties of assistant to the mechanical engineer and head of the steam department.

▲

R. G. Ebert, formerly assistant superintendent of the 42-inch hot strip mills, Gary Sheet and Tin Division, Carnegie-Illinois Steel Corporation, Gary, Indiana, has been named superintendent of those mills. Mr. Ebert was originally employed at the company's American Works at Elwood, Indiana, as a rougher, and after serving as a roller, draftsman, master mechanic, and shop foreman at various plants of the same company was appointed assistant superintendent of the 42-inch hot strip mills at Gary in July 1936.

▲

E. A. Portz, formerly district manager of the Central Alloy district, Republic Steel Corporation, will be assigned home office duties as soon as his health permits. Mr. Portz, who has been ill since early in the year, has been with the Republic Steel Corporation and its predecessor companies since his graduation from Ohio State University in 1913. He started as assistant chemist with the United Steel Company in that year, became general superintendent of the Central Alloy Steel Company in 1926, and district manager for Republic Steel Corporation in 1930.

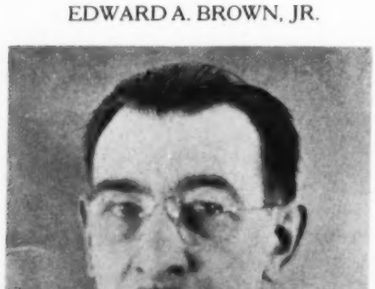
▲

Carl W. Meyers, assistant district manager of the Central Alloy district, Republic Steel Corporation, has been promoted to the position of district manager, succeeding E. A. Portz. The district includes operations in Canton and Massillon. Mr. Meyers became associated with the Upper Works of the Carnegie Steel Company, Youngstown, Ohio, in 1907, and in 1918 went with the McDonald Mill in Youngstown where he stayed until 1931, the last eight years he was superintendent. In 1931 he joined the Republic Steel Corporation, as superintendent of the rolling mill in Chicago and in 1933 was transferred to Youngstown, at the time, the general offices of the Republic Steel Corporation. In 1934 he was made assistant district manager of the Central Alloy district.

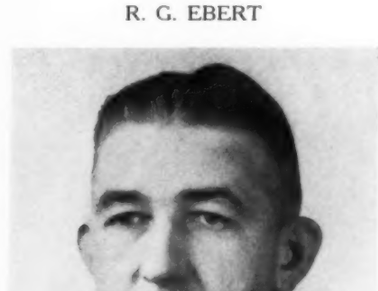
▲

Wade H. Oldham, formerly manager of the Birmingham district, was made district manager of the Birmingham and Gadsden districts, upon their consolidation by the Republic Steel Corporation. Mr. Oldham, a graduate of the University of North

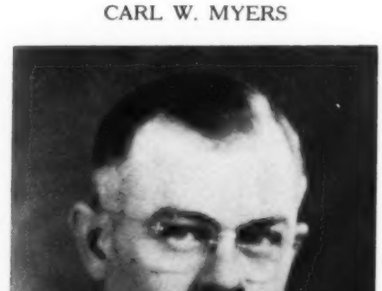
EDWARD A. BROWN, JR.



R. G. EBERT



CARL W. MYERS



EDWARD I. EVANS

CASSIUS F. BIGGERT

GEORGE E. ROSE

Carolina, where he received a Bachelor of Science degree, has been with the corporation since 1929. Previous to that he spent five years as general superintendent of the Fairfield Steel Works, Tennessee Coal, Iron and Railroad Company. He joined the Tennessee Company in 1905 as chemist and in the same year was promoted to blast furnace superintendent, which position he held until 1924.

▲

C. L. Bransford, now assistant district manager, of the Birmingham district, Republic Steel Corporation, has been named general superintendent of the corporation's Birmingham operations. Mr. Bransford, a graduate of the University of North Carolina, specialized in chemical engineering and joined the Tennessee Coal, Iron and Railroad Company as a chemist. He was later made superintendent of the Alace furnace plant in Birmingham, where he worked under Wade H. Oldham. In 1915 he left to go with Gulf States Steel Company as superintendent of blast furnace department and four years later became superintendent of blast furnaces for the Woodward Iron Company. In 1921, Mr. Bransford went with Semet Solvay Company as fuel engineer and later was made general manager of the company's Ashland Kentucky plant. From there he was transferred to Buffalo, New York as superintendent of the company's plant in that city. In 1929 he returned to Birmingham as superintendent of blast furnaces and coke ovens for the old Republic Iron & Steel Company.

▲

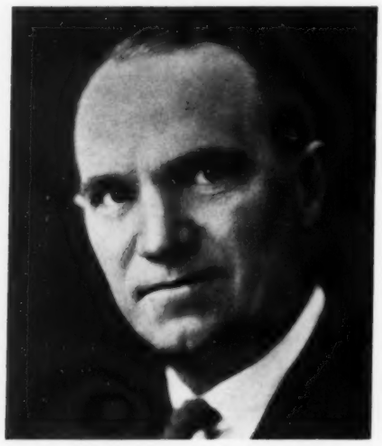
Edward I. Evans, assistant district manager for the Buffalo district, Republic Steel Corporation, has been promoted to general superintendent of the Gulfsteel district with headquarters in Gadsden, Alabama. Mr. Evans was born in Glasgow, Scotland, in 1887 and started his steel career in that city at the age of 12. He came to the United States in 1907, and became associated with the Worth Steel Company, at Coatesville, Pennsylvania, working in the open hearth department. In 1915 he joined the United States Steel Corporation at its Duluth plant and in 1916 returned to the Worth Steel Company, now the Midland Steel Company, as assistant bolt and nut superintendent. Two years later, when Midland Steel removed its plants to Claymont, Delaware, he was made open hearth superintendent. In 1929 he joined the Bourne-Fuller Company, Cleveland, Ohio, as general manager, and three years later was made assistant manager of the Canton district for Republic Steel Corporation. His next move was to Buffalo in 1934 where he held the position of assistant district manager.

▲

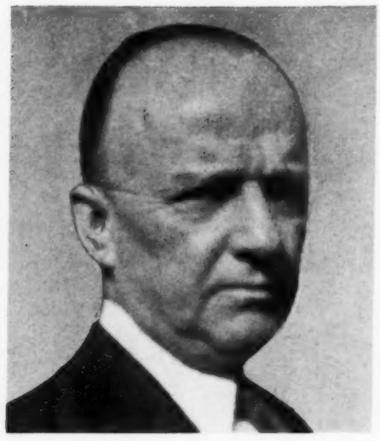
Cassius F. Biggert, vice president in charge of the International Harvester Company's iron and coal mines and the Wisconsin Steel Works, after forty-seven years service retired November 1, 1937. Mr. Biggert began service with the Deering Works, in 1890 in the stores department, and by 1898 was in charge of all raw material purchases except lumber and fiber, devoting himself especially to steel supplies. In 1904, he was called in to the general offices of the newly formed Harvester Company, and in 1915 he was made assistant to Herbert F. Perkins in the conduct of the company's steel and coal operations. He was elected a vice president in 1931.

▲

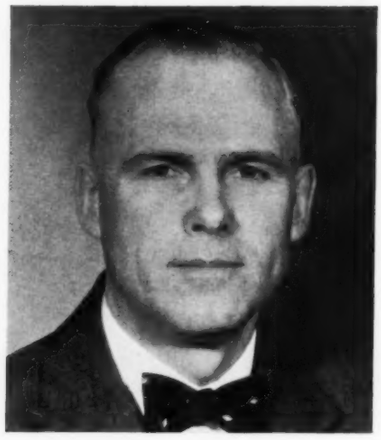
George E. Rose has been elected vice president of the International Harvester Company, in charge of the iron and coal mines and Wisconsin Steel Works. Mr. Rose, formerly the assistant to Cassius F. Biggert, has had thirty-one years of service with the International Harvester Company, spent entirely in connection with the Wisconsin Steel Works. Upon graduation from Princeton University in 1901, he was employed by the Carnegie Steel Company at Braddock, Pennsylvania, in the blast furnace department. By successive promotions he became assistant to the superintendent of blast furnaces, holding that position in 1906 when he began Harvester service as superin-



FRANK C. FARRELL



CHARLES H. BRADLEY



R. A. PETERSON

tendent of blast furnaces at the Wisconsin Steel plant. He was promoted to assistant general superintendent of the steel works in 1909, and in 1912 was appointed general superintendent. Mr. Rose has been Mr. Biggert's assistant since August 1936.

▲

Frank C. Farrell is being transferred to Massillon to succeed Carl W. Meyers as the assistant district manager of the Central Alloy district, Republic Steel Corporation. Mr. Farrell, who has been assistant district manager of the Warren district, started in the steel business in 1903 as water boy in what is now the Carnegie-Illinois Steel Corporation's Youngstown plant. He stayed with this company until 1909, becoming turn foreman in the Bessemer plant. In that year he became associated with Youngstown Sheet and Tube Company, Youngstown, Ohio, in the same capacity, and remained with that company until 1928, at which time he was Youngstown Sheet and Tube Company's Youngstown district manager. In 1928 he went to Cleveland as assistant general manager of Steel & Tubes, Inc., and following the merger was transferred to Warren in 1930, and placed in charge of the Republic Steel Corporation's steel works. In May of this year he was made assistant manager of the Warren district.

▲

Charles H. Bradley, recently an engineer with the Republic Steel Corporation, is now associated with the Wellman Engineering Company, Cleveland, Ohio, as a sales engineer. Mr. Bradley has held several engineering positions with concerns devoted to designing and manufacturing steel plant equipment, as well as with several steel plants. He has been employed by the Heyl & Patterson Company, Pittsburgh, Pennsylvania; the National Tube Company, McKeesport, Pennsylvania; Tennessee Coal, Iron and Railroad Company; Otis Steel Company; and, as chief engineer, the Variety Iron Works, and for sometime had charge of the industrial division of the American Shipbuilding Company, handling blast furnace, steel plant, sintering plant, heavy plate and machine work.

▲

R. A. Peterson will be the superintendent of the merchant bar mills, Carnegie-Illinois Steel Corporation, Gary, Indiana. Mr. Peterson has been with the United States Steel Corporation subsidiaries since March 1934. He began with the American Steel & Wire Company at Cleveland as mill adviser, coming there from the Aetna Standard Engineering Company at Youngstown, Ohio, where he was manager of heavy mill sales. In May 1936 he was transferred to Gary Works of Carnegie-Illinois Steel Corporation, where he served as assistant superintendent of the merchant, axle and wheel mills until the present time.

▲

C. S. Ramsay was appointed assistant superintendent of the merchant bar mills, Gary Works,

C. S. RAMSAY

ADVERTISING PAGES REMOVED

S. R. STANIER

R. B. LUCAS

GEORGE TREE

Carnegie-Illinois Steel Corporation, succeeding R. A. Peterson. Mr. Ramsay began with the Tennessee Coal, Iron and Railroad Company, a United States Steel Corporation subsidiary, at Birmingham, Alabama, in 1897 and was employed there until 1910, when he was transferred to the rail mill at Gary Works of Carnegie-Illinois Steel Corporation. A short time later he was moved to the merchant mills and has been assistant superintendent of those mills in charge of rolling since 1922.

▲

S. R. Stanier has just been appointed as superintendent of the hot strip mills, Gary Works, Carnegie-Illinois Steel Corporation, Gary, Indiana. Mr. Stanier was originally employed at the Gary Sheet and Tin Division of Carnegie-Illinois Steel Corporation in October 1927, and serving there until July 1936, he was transferred to the Gary Works as assistant superintendent of the 38″ strip mill.

S. L. MOFFATT

R. B. Lucas, assistant superintendent of the wheel mill, Gary Works, Carnegie-Illinois Steel Corporation, was made the superintendent of the wheel and axle mills. Mr. Lucas has been employed continuously at Gary Works since he began as a foreman in the merchant mills in 1911. After working in various capacities, he was made assistant superintendent of the wheel mill in 1934, the position he held until the present time.

▲

George Tree was appointed superintendent of maintenance, west division, Gary Works, Carnegie-Illinois Steel Corporation. Mr. Tree was first employed at the Gary Works as a helper in the merchant mills in 1912, and after serving continuously in various capacities, was appointed assistant superintendent of these mills in 1934.

▲

S. L. Moffatt has been appointed superintendent of No. 4 open hearth furnace, Gary Works, Carnegie-Illinois Steel Corporation. Mr. Moffatt began with the American Steel & Wire Company, a United States Steel Corporation subsidiary, in 1914. After eleven years there he left and was employed by the Otis Steel Company until 1929, when he returned to the corporation as a first helper at No. 3 open hearth furnace at Gary Works. He has been assistant superintendent of No. 4 open hearth since June 1933.

▲

Charles P. Betz has been appointed superintendent of the new coke plant, now being erected by the Hanna Furnace division of Great Lakes Steel Corporation, Detroit, Michigan. A graduate of Case School of Applied Science, Cleveland, Ohio, Mr. Betz was associated with the Central Furnace division of American Steel and Wire Company, of Cleveland, until 1916, when he became active with the coke oven department of Youngstown Sheet and Tube Company, Youngstown, Ohio, continuing there until 1926, when he was named superintendent of coke plant for the Central Alloy plant of Republic Iron and Steel

Company, Massillon, Ohio, later the Central Alloy division of Republic Steel Corporation. The Great Lakes coke plant will be placed in operation about January 1, 1938.

▲

Jones & Laughlin Steel Corporation, Pittsburgh, Pennsylvania, has appointed L. A. Lambing, superintendent of the open hearth and bessemer department at the Pittsburgh works, and W. A. Holt, superintendent of the blooming mill. F. L. Raum is superintendent of the mill ordering and shipping department; J. M. Morris, superintendent of the new maintenance department; and C. J. Wyrough, superintendent of steam efficiency.

▲

Died

William Hilditch, general master mechanic, Great Lakes Steel Corporation, Ecorse, Michigan, at Detroit on November 13. Mr. Hilditch was born in Lincoln, England, in 1884, and was five years of age when he came to the United States with his parents. He served his machinist apprenticeship with the American Steel and Wire Company, division of the United States Steel Corporation. At the completion of his apprenticeship he went to the Otis Steel Company of Cleveland, where he worked for twenty-three years, first as a machinist and then as machine shop foreman. He was later promoted to assistant master mechanic, and then to general master mechanic, and finally to chief engineer. He left the Otis Steel Company and worked a year for the Jones and Laughlin Steel Corporation, then started in business for himself as a construction contractor. After two years, he went to the Wheeling Steel Corporation as general master mechanic and superintendent in charge of construction. In 1930, he became general master mechanic of the Great Lakes Steel Corporation of Ecorse, Detroit, Michigan, which position he held at the time of his death. He was an active member of the Association of Iron and Steel Engineers.

WILLIAM HILDITCH

Homer D. Williams, 74, one-time associate of Andrew Carnegie and who retired in 1936 as president of the Pittsburgh Steel Company after 55 years of steel making, died in the University of Maryland Hospital, Baltimore, where he had been a patient since last July.

Homer D. Williams had a public school education and in 1880 began work as a carbon boy in the Cambria Steel Company.

Five years later, deciding to devote his life to steel making, Williams had matriculated at Lehigh University, where he took three courses in chemistry and metallurgy. He became a chemist in Chicago for the Illinois Steel Company, and later for the Colby Mine, Bessemer, Mich.

At the turn of the century in 1899, Mr. Williams took charge of the Bessemer converter at the Homestead plant of the Carnegie Steel Company. Fifteen years later, in 1914, he was the new president of Carnegie Steel.

After 11 years as chief executive of Carnegie Steel, Williams resigned to accept the presidency of the Pittsburgh Steel Company. And 11 years later on February 1, 1936, he resigned—the last of his generation of steelmasters—for a quieter life in retirement.

▲

C. E. Bedell, electrical engineer for Mesta Machine Company, on November 5, 1937. Mr. Bedell was one of the oldest members of the Association of Iron and Steel Engineers, having joined the Association October 1, 1910. He has served on many national committees of the Association, and has always been a very liberal contributor to the editorial columns of the IRON AND STEEL ENGINEER and the Association's Transactions.

Mr. Bedell had been with the Mesta Machine Company as an electrical engineer since 1931. He had formerly been with the Wheeling Steel Corporation at the Benwood Plant.

▲

Robert Arthur Carnahan, 33, Pittsburgh representative of the Nukem Products Corporation, enroute to Tucson, Arizona for his health, died at Douglas, Arizona, on October 19, 1937. Mr. Carnahan, prior to the position he held until his recent death, had held many engineering positions in the State of Ohio. He was a member of the Association of Iron and Steel Engineers.

The Association has on hand at the national office, 1010 Empire Building, Pittsburgh, Penna., a supply of the new Association pins. Every member should have one of these attractive insignias. The cost is $1.00.

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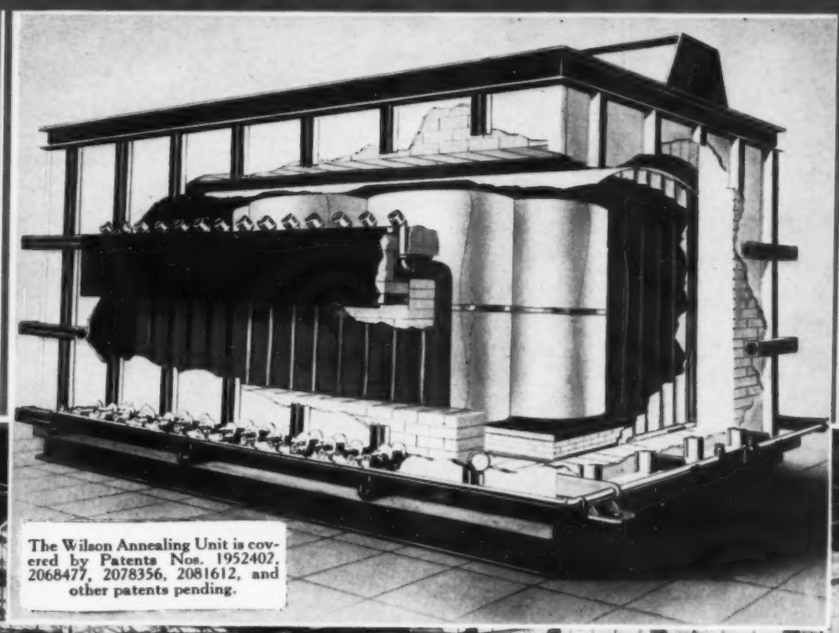

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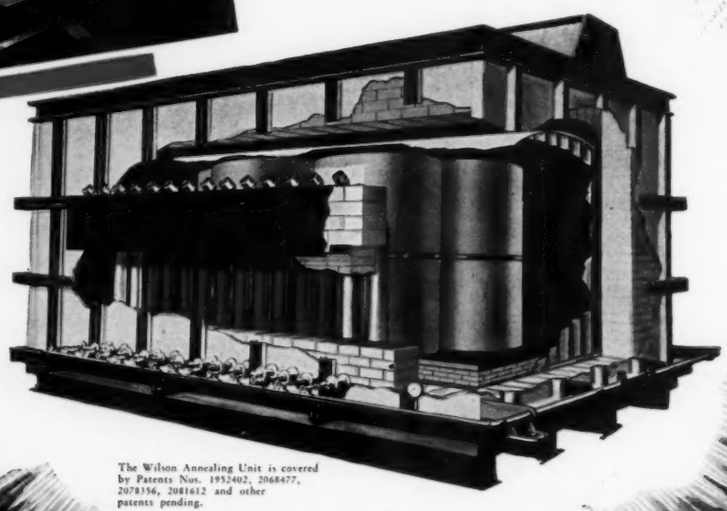

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